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WEIGHT CONCERNS AND ABDOMINAL OBESITY AMONG EVER-SMOKERS:

A POPULATION-BASED STUDY OF FINNISH ADULTS

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ACADEMIC DISSERTATION

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For my family

ABSTRACT

Smoking-specific weight concerns are one factor involved in smoking and the smoking cessation process. Previous literature has reported inconsistent findings regarding the association of weight concerns with self-efficacy and motivation to quit. In addition, inconsistent findings about smoking-specific weight concerns as an obstacle for quitting have been reported. Even though daily smokers tend to weigh less, they tend to have more abdominal obesity than never smokers. This thesis aimed to assess the level of smoking-specific weight concerns according to smoking status, the association of weight concerns with self-efficacy and motivation to quit, and weight concerns as a predictor of subsequent smoking status in the Finnish adult population. An additional aim was to assess the association of smoking with abdominal obesity.

This thesis is based on national FINRISK/DILGOM studies conducted in 2007 and 2014. Four different datasets were used in this study. In 2007, a population-based sample of 10,000 Finnish people (67% participation rate) aged 25 to 74 years from six geographical regions was drawn from the Population Register to form FINRISK 2007. FINRISK 2007 data was used in Study IV. DILGOM 2007, a subsample of FINRISK 2007, was formed to study metabolic factors and obesity. Studies I and II utilised a special sub-sample of ever smokers identified within the DILGOM 2007 study. A sub-sample of ever smokers and follow-up DILGOM 2014 was used in Study III. Smoking status was mainly self-reported, with biochemically-verified data among sub-samples. Weight concerns were measured by a modified Weight Concern Scale administered in the 2007 questionnaire, and nicotine dependence by the Fagerström Test for Nicotine Dependence (FTND). Self-efficacy and motivation to quit, as well as the majority of confounders, were also self-reported measures. Weight, height, waist circumference, and expired air carbon monoxide were measured by study nurses. Cotinine, a metabolite of nicotine, was derived from blood samples.

Daily smokers were found to have higher levels of weight concerns compared to occasional smokers, recent quitters, and former smokers. Among daily smokers, weight concerns were associated with lower self-efficacy to quit but not with lower motivation to quit. Nicotine dependence attenuated the association between weight concerns and self-efficacy to quit. Baseline weight concerns predicted smoking cessation and reduced tobacco usage by 2014 (from daily smoking to occasional use) among those daily smokers with low nicotine dependence (FTND 0–3), but not among those with high nicotine dependence (FTND ≥4). The association of smoking status with abdominal obesity was significant among women who were overweight/obese heavy daily (≥20 cigarettes per day) or ex-smokers.

Daily smokers report more weight concerns compared to other ever smokers. Weight concerns are associated with a lower self-efficacy to quit among daily smokers. Weight concerns predict subsequent smoking status only among smokers who are not highly dependent on nicotine. Hence, in the Finnish population, weight concerns seem to have a role in some factors involved in the smoking cessation process. However, considering

successful cessation as the outcome, those concerns seem to interplay with nicotine dependence. Among overweight/obese women, daily heavy smokers and ex-smokers have more abdominal obesity compared to never smokers. Further investigations in clinical settings, including longitudinal designs and repeated measurements during the smoking cessation process, may be useful to provide a deeper understanding of the complex interplay between weight concerns and other determinants of smoking cessation.

TIIVISTELMÄ

Yhtenä syynä tupakoinnin jatkamiselle ovat tupakointiin liittyvät painohuolet. Näiden tupakointiin liittyvien painohuolten yhteyksiä tupakointiin ja tupakoinnin lopettamiseen on tutkittu suhteellisen paljon, mutta vähemmän väestötasolla. Tulokset painohuolten yhteydestä pystyvyyden tunteeseen ja motivaatioon lopettaa tupakointi ovat olleet keskenään ristiriitaisia. Myös tulokset painohuolten tupakoinnin lopettamista ennustavana tekijänä ovat olleet keskenään ristiriitaisia. Lisäksi, vaikka päivittäistupakoitsijat keskimäärin painavat vähemmän kuin he, jotka eivät ole koskaan tupakoineet, päivittäistupakoitsijoilla on joissakin tutkimuksissa havaittu olevan enemmän vyötärölihavuutta. Tämän väitöstutkimuksen tavoitteena oli verrata tupakointiin liittyvien painohuolten tasoa päivittäistupakoitsijoiden, satunnaistupakoitsijoiden, tupakoinnin äskettäin lopettaneiden, ja ≥6 kuukautta sitten lopettaneiden kesken. Lisäksi tutkittiin päivittäistupakoitsijoiden painohuolten yhteyttä pystyvyyden tunteeseen ja motivaatioon lopettaa tupakointi, sekä painohuolia tupakoinnin lopettamista ennustavana tekijänä. Tavoitteena oli myös tutkia tupakoinnin yhteyttä vyötärölihavuuteen.

Väitöstutkimuksessa käytettiin väestöpohjaista FINRISKI 2007 -tutkimusaineistoa, sekä sen alaotosta DILGOM 2007 -aineistoa. Lisäksi käytettiin DILGOM-aineiston tupakoitsijoita koskevaa alaotosta, sekä seuranta-aineistona DILGOM 2014 -aineistoa. FINRISKI 2007 -aineistoon poimittiin satunnaisotannalla väestörekisteristä 10 000 ihmistä kuudelta alueelta Suomesta, ja heille lähetetyn kyselyn vastausprosentti oli 67. Tutkittavat olivat iältään 25–74-vuotiaita. FINRISKI 2007 -aineistoa käytettiin väitöstutkimuksen IV-osatyössä, tupakoitsijoiden alaotosta käytettiin osatöissä I ja II, ja tupakoitsijoiden alaotos- sekä DILGOM 2014 -aineistoja käytettiin III-osatyössä. Tupakointi oli näissä aineistoissa pääosin itseraportoitua, mutta osatöissä III–IV käytettiin lisäksi alaotosta, jossa itseraportoitu tupakointi tai tupakoimattomuus oli biokemiallisesti varmistettu. Painohuolet mitattiin muokatulla Weight Concerns Scale-mittarilla, ja nikotiiniriippuvuus Fagerströmin nikotiiniriippuvuus-testillä (FTND). Pystyvyyden tunne ja motivaatio lopettaa tupakointi, kuten pääosa vakioitavista tekijöistä, olivat tutkimuksessa käytetyissä aineistoissa itseraportoituja. Paino, pituus, vyötärönympärys sekä hengitysilman häkä olivat tutkimushoitajien mittaamia. Nikotiinin metaboliitti kotiniini mitattiin verinäytteestä.

Päivittäistupakoitsijoilla oli keskimäärin enemmän tupakointiin liittyviä painohuolia verrattuna satunnaistupakoitsijoihin sekä äskettäin ja ≥6 kuukautta sitten tupakoinnin lopettaneisiin. Päivittäistupakoitsijoilla voimakkaammat painohuolet olivat yhteydessä vähäisempään pystyvyyden tunteeseen lopettaa tupakointi, mutta nikotiiniriippuvuus heikensi kyseistä yhteyttä. Sen sijaan tilastollisesti merkitsevää yhteyttä painohuolten ja tupakoinnin lopettamismotivaation välillä ei ollut. Mitä enemmän päivittäistupakoitsijalla oli painohuolia vuonna 2007, sitä epätodennäköisempää tupakoinnin lopettaminen ja siirtyminen päivittäistupakoinnista satunnaiseen tupakointiin vuoteen 2014 mennessä oli niillä päivittäistupakoitsijoille, joilla nikotiiniriippuvuus oli vähäistä (FTND 0–3). Niillä

päivittäistupakoitsijoilla, joilla oli kohtalainen tai voimakas nikotiiniriippuvuus (FTND ≥4), vuonna 2007, painohuolten taso ei ennustanut tupakoinnin lopettamista tai siirtymistä satunnaiseen tupakointiin. Runsaasti päivittäin tupakoivilla (≥20 savuketta päivässä) sekä tupakoinnin lopettaneilla tupakointi oli yhteydessä vyötärölihavuuteen ylipainoisilla ja lihavilla naisilla verrattuna naisiin, jotka eivät olleet koskaan tupakoineet.

Tässä väitöstutkimuksessa todettiin, että päivittäistupakoitsijoilla on enemmän tupakointiin liittyviä painohuolia kuin muilla tupakoitsijoilla, ja heillä painohuolet ovat yhteydessä vähäisempään pystyvyyden tunteeseen lopettaa tupakointi. Painohuolet ennustavat myöhempää tupakointi-statusta vain niillä päivittäin tupakoivilla, joiden nikotiiniriippuvuuden aste on vähäinen. Suomalaisessa väestössä painohuolet näyttäisivät olevan yhteydessä pystyvyyden tunteeseen lopettaa tupakointi. Lisäksi painohuolet ja nikotiiniriippuvuus vaikuttavat tupakoinnin lopettamiseen vuorovaikutuksessa toisiinsa. Ylipainoisilla ja lihavilla naisilla runsas päivittäinen tupakointi sekä aiempi tupakointi ovat yhteydessä vyötärölihavuuteen. Tutkimuksia olisi hyvä jatkaa kliinisillä, toistuvia painohuolimittauksia sisältävillä pitkittäisillä aineistoilla. Tämä toisi lisätietoa painohuolien yhteydestä muihin tupakoinnin lopettamiseen liittyviin tekijöihin.

CONTENTS

LIST OF ORIGINAL PUBLICATIONS

This thesis is based on the following original articles referred to in the text by their Roman numerals:

I. Luostarinen M, **Tuovinen EL**, Saarni SE, Kinnunen T, Hukkinen M, Haukkala A, Patja K, Kaprio J, Korhonen T. Weight concerns among Finnish ever-smokers: A population-based study. Nicotine Tob Res. 2013 Oct; 15(10):1696-704.

II. **Tuovinen EL**, Saarni SE, Kinnunen TH, Haukkala A, Jousilahti P, Patja K, Kaprio J, Korhonen T. Associations of weight concerns with self-efficacy and motivation to quit smoking: A population-based study among Finnish daily smokers. Nicotine Tob Res. 2015 Sep; 17(9):1134-41.

III. **Tuovinen EL**, Saarni SE, Kinnunen TH, Ollila H, Ruokolainen O, Patja K, Männistö S, Jousilahti P, Kaprio J, Korhonen T. Weight concerns as a predictor of smoking cessation according to nicotine dependence: A population-based study. Submitted.

IV. **Tuovinen EL**, Saarni SE, Männistö S, Borodulin K, Patja K, Kinnunen TH, Kaprio J, Korhonen T. Smoking status and abdominal obesity among normal- and overweight/obese adults: Population-based FINRISK study. Prev Med Rep. 2016 Dec; 4: 324–330.

Abbreviations

ANOVA	analyses of variance
APA	American Psychiatric Association
β	beta coefficient
BMI	body mass index
CI	confidence interval
CO	carbon monoxide
COM-B System	model of behaviour change consisting of capability, opportunity and motivation
CPD	cigarettes per day
CVD	cardiovascular disease
DILGOM	Dietary, Lifestyle and Genetic Determinants of Obesity and Metabolic Syndrome
FTCD	Fagerström Test for Cigarette Dependence
FTND	Fagerström Test for Nicotine Dependence
FTQ	Fagerström Tolerance Questionnaire
HSI	Heaviness of Smoking Index
LR χ^2	likelihood ratio chi-square
NCHS	National Center for Health Statistics
NRT	nicotine replacement therapy
OR	odds ratio
RRR	relative risk ratio
RCT	randomized controlled trial
SSQ	Smoking Situations Questionnaire
SWEET	Smoking-Related Weight and Eating Episodes Test
UK	United Kingdom
USDHHS	U.S. Department of Health and Human Services
WHR	waist-to-hip circumference ratio
WCSS	Weight Control Smoking Scale
WHO	World Health Organization

1 Introduction

Smoking and obesity are among the five leading preventable causes of morbidity and mortality worldwide (Benziger, Roth & Moran 2016). Since both of these are quite common at the population level, they are major public health problems. In 2015, over 1.1 billion people smoked worldwide (World Health Organization 2015). In Finland, 15.6% of adult men and 10.7% of women were daily smokers in 2017 (Koponen et al. 2018), however, the smoking prevalence in Finland is decreasing, with the aim for Finland to be tobacco-free by 2030 (Tobacco-free Finland 2030 network 2017). While the smoking prevalence in many countries, including Finland, is decreasing, the prevalence of being overweight and obese is increasing (Ng, Fleming et al. 2014, Ng, Freeman et al. 2014). Thus, the world is in an epidemic state, with 2.1 billion overweight or obese people.

Abdominal obesity is known to be more hazardous to one's health than general obesity (Carmienke et al. 2013). In addition, unhealthy habits tend to cluster within the same people (Noble et al. 2015). The combination of smoking and obesity poses an additional risk (Peeters et al. 2003). Obese smokers lose, on average, 13 years of life, while those with only one of these risk factors lose, on average, 6 to 7 years. In general, even though daily smokers tend to weigh less, they tend to have more abdominal obesity than never smokers (Berlin 2008, Chiolero et al. 2008, Shi, An & Meijgaard 2013). Further, the average weight gain following smoking cessation is four to five kilograms (Aubin et al. 2012, Tian et al. 2015). Ex-smokers tend to both weigh more and have more abdominal obesity compared to never smokers (Klesges et al. 1989, Tian et al. 2015).

Among daily smoking women and men, 50% and 19–26%, respectively, have smoking-related weight concerns (French & Jeffery 1995, Clark et al. 2006, Pankova et al. 2016). These concerns are a multi-dimensional construct regarding the smokers' fear of weight gain and obesity (French & Jeffery 1995). Weight concerns underlie an individual's smoking initiation (French & Jeffery 1995, Potter et al. 2004, U.S. Department of Health and Human Services 2012) and continued smoking (USDHHS 2012). Young adults, women, and overweight/obese people are more likely to have smoking-related weight concerns (French & Jeffery 1995, Germeroth & Levine 2018). In addition, daily smokers have higher weight concern levels compared to other smokers (French & Jeffery 1995).

The majority of smokers want to quit smoking (Helldán, Helakorpi 2015), and an average of 40% attempt to quit during a given year (Borland et al. 2012). However, successful cessation usually requires many attempts (Chaiton et al. 2016, Curry & McBride 1994). Nicotine dependence is the main reason why smokers fail to quit (Vangeli et al. 2011), but weight concerns have been suggested to be amongst other barriers to smoking cessation (French & Jeffery 1995). These smoking-related weight concerns may reduce cessation rates (French & Jeffery 1995, Germeroth & Levine 2018).

This thesis focuses on smoking-specific weight concerns in a population-based sample of Finnish adults. Further, this thesis also provides insight into the relationship between

smoking and abdominal obesity, a dimension of being overweight with major health consequences. A challenge for healthcare is to better understand the role of weight concerns in the smoking cessation process. This thesis aims to provide evidence-based knowledge to address these matters. First, levels of weight concerns among various groups of ever-smoking men and women are described. Second, among daily smokers, associations of weight concerns with self-efficacy and motivation to quit are assessed. Third, weight concerns as a predictor of subsequent smoking status is investigated. Finally, the association between smoking and abdominal obesity is demonstrated. Such understanding about weight concerns and abdominal obesity according to smoking at population level would help to develop more effective cessation programs, especially for weight-concerned smokers.

2 Review of the literature

This study focuses primarily on smoking-specific weight concerns, and their associations with various smoking-related factors. Secondly, the focus is on the associations of smoking with weight and abdominal obesity. This review is mainly restricted to studies on adults, both in general and in clinical samples. Adolescent smokers and diverse subgroups (pregnant women, etc.) may be different and, hence, are mainly excluded from this review.

2.1 Introduction to the main concepts of the study

2.1.1 Smoking-related weight concerns

Weight concerns is a multidimensional construct. The dimensions of smoking-related weight concerns defined by French and Jeffery (1995) include: "1) weight gain concerns/fears of weight gain, 2) dieting behaviours, 3) dispositional weight concerns/dieting behaviours, and 4) perceptions of overweight." The first dimension of smoking-specific weight concerns are concerns of gaining weight or a fear of obesity. These concerns refer to an exaggerated fear of weight gain, which then may lead to the second dimension of weight concerns, dieting behaviours. Dieting behaviours are behavioural markers of weight concerns, an indirect way to measure weight concerns. Dieting behaviours reflect weight concerns, but may also be driven by health-related motivations. Dieting behaviours are mainly assessed by direct questions about current and previous efforts to lose weight. The third dimension of weight concerns are dispositional weight concerns and dieting behaviours referring to eating behaviours where a person is alternating between periods of dietary restrictions and disruptions. Many scales, such as the Three Factor Eating Questionnaire (Stunkard & Messick 1985), have been applied to measure dispositional weight concerns and dieting behaviours (French, & Jeffery 1995). The last dimension of weight concerns is perceived overweightness, which refers to a person's perception of being overweight without actually meeting clinical overweight criteria. Perceived overweightness can be assessed indirectly by asking what the person's current and desired weight are, and calculating the difference between them. A major difference between actual and ideal body weight reflects body dissatisfaction and thus weight concerns. A direct way to measure perceived overweightness is to ask whether the person would like to be thinner, heavier, or about the same weight as they are. Of note, this last dimension cannot be assessed from overweight/obese people.

Smoking-related weight concerns can be measured by smoking-specific questions applicable for ever-smokers only or by general weight concern questions applicable for both never- and ever-smokers. This thesis focuses mainly on smoking-specific weight concerns. To assess smoking-specific weight concerns, different questionnaires have been developed and widely used in research (Borrelli & Mermelstein 1998, Meyers et al. 1997, Weekley,

Klesges & Reylea 1992, Perkins et al. 2001, Pomerleau & Saules 2007, French & Jeffery 1995, Jeffery et al. 2000). In addition, smoking-specific weight concerns have been measured with a single question only (French & Jeffery 1995, Rosenthal et al. 2013). One smoking-specific weight concerns questionnaire, the weight control smoking scale (WCSS), has been validated and tested for reliability (Pomerleau & Snedecor 2008). The WCSS, however, measures only one dimension of weight concerns, dieting behaviours. The different weight concern scales have had high internal consistencies in different populations (Borrelli & Mermelstein 1998, Pomerleau & Snedecor 2008, Zhou et al. 2009, Pinsker et al. 2017). A slightly modified version of Borrelli and Mermelstein's Weight Concern Scale was applied to measure smoking-specific weight concerns in this thesis. The main smoking-specific weight concern scales are presented in Table 1. Of note, in addition to weight concerns, one's self-efficacy to prevent weight gain has also been studied (Borrelli & Mermelstein 1998). However, self-efficacy to prevent weight gain was not assessed in this thesis.

General weight concerns have also been measured with a single question (Landrau-Cribbs, Cabriales & Cooper 2015, French & Jeffery 1995) or with a series of questions (Pisinger & Jorgensen 2007b, French & Jeffery 1995). An example of specific wording for a general weight concerns assessment related to smoking is shown in Table 2. The advantage of applying general weight concerns is that it enables the comparison between never- and ever-smokers, while smoking-specific weight concern scales are restricted to ever-smokers only. This thesis's main focus is on smoking-specific weight concerns.

Table 1. *The main assessment to measure smoking-specific weight concerns related to smoking cessation.*

Smoking-specific scales		
First author year	Items	Response options
French 1992	If you were to quit smoking, how concerned would you be about the possibility of gaining weight?	1 (not at all concerned) to 5 (extremely concerned)
Weekley 1992	Smoking Situations Questionnaire (SSQ) 1. I continue to smoke so that I don't gain weight 2. I started to smoke to control my weight 3. If I stop smoking, I will gain weight 4. I often smoke to kill my appetite when I get hungry 5. I smoke at the end of a meal so I won't eat too much 6. I smoke instead of snacking when I am bored	1 (completely disagree) to 6 (completely agree)
Meyers 1997	Concern about weight gain 1. If after quitting smoking you gained 18–20 lbs. [8.16–9.07 kg], would you start smoking again? 2. If after quitting smoking you gained 16–18 lbs. [7.23–8.16 kg], would you start smoking again? 3. If after quitting smoking you gained 14–16 lbs. [6.35–7.23 kg], would you start smoking again?	Yes/No Dichotomy: non-weight-concerned or weight-concerned

	4. If after quitting smoking you gained 12–14 lbs. [5.44–6.35 kg], would you start smoking again? 5. If after quitting smoking you gained 10–12 lbs. [4.54–5.44 kg], would you start smoking again? 6. If after quitting smoking you gained 8–10 lbs. [3.63–4.54 kg], would you start smoking again? 7. If after quitting smoking you gained 6–8 lbs. [2.72–3.63 kg], would you start smoking again? 8. If after quitting smoking you gained 4–6 lbs. [1.81–2.72 kg], would you start smoking again? 9. If after quitting smoking you gained 2–4 lbs. [0.91–1.81 kg], would you start smoking again? 10. If after quitting smoking you gained less than 2 lbs. [0.91 kg], would you start smoking again?	
Borrelli 1998	Weight Concern Scale 1. How important is losing weight or maintaining your current weight compared with other personal health concerns? 2. People smoke for many reasons. Compared with all of your reasons for smoking, how important is smoking to control your weight? 3. How much do cigarettes help you to control your weight? 4. How concerned are you about gaining weight as a result of quitting smoking? 5. How likely do you think it is that you will gain weight as a result of quitting? 6. How likely is it that you would go back to smoking after quitting if you gained too much weight?	1 (not at all) to 10 (very much)
Jeffery 2000	1. How concerned would you be about the possibility of gaining weight after quitting smoking? (Specific wording not provided) 2. If you gained 5 lbs. [2.3 kg] from quitting smoking, how confident are you that you could lose it?	1 (not at all concerned) to 5 (extremely concerned) 1 (not at all confident) to 3 (very confident)
Perkins 2001	Weight gain concerns 1. How concerned are you about gaining weight after quitting? 2. How concerned would you be if quitting smoking caused you to permanently gain 10 lbs. [4.5 kg]?	0 (not at all) to 100 (extremely)
Pomerleau 2007	Weight Control Smoking Scale (WCSS) 1. I smoke to keep from gaining weight 2. Smoking helps me control my appetite 3. I don't get so hungry when I smoke	0 (not at all) to 3 (very much so)
Rash 2008	Weight control 1. Smoking keeps my weight down 2. Smoking helps control my weight 3. Cigarettes keep me from eating more than I should	0 (not at all likely) to 6 (extremely likely)

Adams 2011	Smoking-Related Weight and Eating Test (SWEET) <u>Smoking to suppress appetite</u> 1. When I feel hungry, I have a cigarette to curb my appetite 2. When I crave unhealthy food, I have a cigarette to avoid eating 3. When I feel like having a snack, I have a cigarette instead <u>Smoking to prevent overeating</u> 1. If I don't smoke soon after a meal, I continue to eat more than I need 2. Smoking after a meal helps me to avoid overeating 3. When I am full, I smoke so that I won't eat more <u>Smoking to cope with body dissatisfaction</u> 1. When I feel fat, I have a cigarette 2. I smoke when I am worried about gaining weight <u>Withdrawal-related appetite increases</u> 1. I crave tasty foods when I haven't smoked in a while 2. I feel hungrier when I haven't smoked in a while	1 (never) to 5 (always)

Table 2. *Assessment to measure general weight concerns related to smoking.*

First author year	Items
Pisinger 2007	<u>Weight concerns</u> I am never concerned of my weight I am sometimes concerned of my weight I am often concerned of my weight I am always concerned of my weight <u>Eating patterns</u> I eat what I want without being concerned of my weight I eat what I want but go on a diet on and of I eat what I want but I am always concerned of my weight I am always on a diet/ I am very aware of what I eat, and always concerned of my weight

2.1.2 General and abdominal obesity

The World Health Organization's (WHO) definition for obesity is the following: "a condition of abnormal or excessive fat accumulation in adipose tissue, to the extent that health may be impaired" (WHO 2000). The classification of normal weight, overweight and obesity is presented in Table 3.

Table 3. *The combined association of body mass index (BMI) and waist circumference with disease risk in adults. Modified from WHO 2011. Used with permission.*

Weight Status	Body mass index	Disease risk (relative to normal weight and waist circumference)	
		Men ≤ 102 cm Women ≤ 88 cm	Men >102 cm Women >88 cm
Underweight	<18.5		
Normal	18.5–24.9		
Overweight	25.0–29.9	Increased	High
Obesity	30.0–34.9	High	Very high
	35.0–39.9	Very high	Very high
Extreme obesity	>40.0	Extremely high	Extremely high

Worldwide, approximately 2.1 billion people were overweight or obese in 2013 (Ng et al. 2014). Globally, from 1980 to 2013, the proportion of overweight/obese adults has increased from 29% to 37% in men, and from 30% to 38% in women (Ng et al. 2014). In Finland, the mean body mass index (BMI) has been increasing since the 1970s among men and since the 1980s among women (Männistö et al. 2015). Since the early 2000s, the increase in mean BMIs seems to have slowed down (Männistö et al. 2015, Koponen et al. 2018). In 2017, among people over 30 years old, 45.8% of men and 35.8% of women were overweight and 26.1% of men and 27.5% of women were obese in Finland (Koponen et al. 2018).

BMI is the most commonly used index of 'weight-for-height' to classify adults according to their weight and assess overweightness and obesity (WHO 2000). The formula for BMI is *weight in kilograms divided by the square of height in meters (kg/m^2)*. BMI is the most useful, but somewhat crude, measurement to estimate overweightness and obesity and associated health risks at the population level. The all-cause mortality risk associated with BMI is continuous with a J-shaped curve (Aune et al. 2016). The nadir of the curve is from 20 to 24. Obese individuals, especially those with excess adipose tissue in the intra-abdominal depots, have an increased risk for the detrimental health consequences such as cardiovascular and metabolic adversities. However, BMI does not encompass embody adipose tissue dispersion, and therefore does not correspond with associated health risks as well as straight abdominal obesity measurement.

At the population level, abdominal obesity can be estimated by waist circumference measurement (WHO 2000). Ethnic populations differ in associations between waist circumference and health risk, therefore, different waist circumference cut-offs are applied according to genetic origin. In 2005, the International Diabetes Federation introduced a grading system, which has become globally accepted (Alberti et al. 2005). The cut-offs for Europeans, including Finns, are presented in Table 3. Another measurement to assess abdominal obesity is the waist-to-hip circumference ratio (WHR) (WHO 2000). The cut-off points for abdominal obesity with WHR are ≥0.90 for men and ≥0.85 for women (WHO 2011). Waist circumference and WHR have showed similar risks of mortality for upper quantiles (Carmienke et al. 2013). Waist circumference alone, however, provides a more practical tool to assess abdominal obesity in both research and clinical settings. Abdominal obesity was assessed applying waist circumference measurements in this thesis.

General overweightness and obesity increase the risk for various diseases, such as cardiovascular diseases (CVD) (Heymsfield & Wadden 2017), diabetes (Heymsfield & Wadden 2017), various cancers (Lauby-Secretan et al. 2016), and dementia (Loef &Walach 2013, O'Brien et al. 2017). Similarly, abdominal obesity increases the risk for CVDs (O'Neill & O'Driscoll 2014), diabetes (Seo, Choe & Torabi 2017), various cancers (Ma et al. 2013, Chen et al. 2016, Hidayat et al. 2016), and dementia (O'Brien et al. 2017). Further, both general and abdominal obesity increase overall mortality (Carmienke et al. 2013).

2.1.3 Smoking status

Previously, WHO guidelines recommended the following smoking status classification: daily smokers, occasional smokers and non-smokers (Ramström 1988). Daily smokers included those who currently smoked some kind of tobacco products on a daily basis and occasional smokers those who smoked, but less than once a day. Further, non-smokers were those who did not smoke at all at the time of assessment. This group could further be divided into ex-smokers and other non-smokers. Ex-smokers included those who had smoked daily for at least six months but had quit smoking and other non-smokers included those who had never smoked and those who had ever smoked less than six months during their lifetime. Later, the classification was defined more narrowly, because ex-smokers and other non-smokers constitute heterogeneous sub-groups.

Nowadays, in the field of smoking research, adults are recommended to be classified into two main categories: never- and ever-smokers (National Center for Health Statistics 2017). Never-smokers are usually defined as those who have never smoked or have smoked less than 100 cigarettes during their lifetime. Further, ever-smokers are those who have smoked at least 100 cigarettes in their lifetime. Ever-smokers are recommended to be further categorised into three main subgroups: current daily smokers, occasional smokers, and ex-smokers. In 2017, among people over 30 years old, 15.6% of men and 10.7% of women

were daily smokers and 7.9% of men and 5.0% of women were occasional smokers in Finland (Koponen et al. 2018).

A widely used definition for current daily smoking is as follows: those ever-smokers who currently smoke on a daily basis (NCHS 2017). Moreover, daily current smokers can be further categorised according to cigarettes smoked per day (CPD). According to CPD, the following groupings have widely been applied: light, moderate and heavy smokers. The applied CPD thresholds vary. For example, when examining light versus heavy smokers, ≥20 has been the boundary (Rasouli et al. 2013). In the case where current daily smokers are divided into light, moderate and heavy, example cut-offs have been: 1–9 CPD, 10–19 CPD, and ≥20 CPD (Clair et al. 2011), or 1–10 CPD, 11–20 CPD, and >20 CPD (Slagter et al. 2013, de Oliveira Fontes Gasperin et al. 2014).

Occasional smokers fulfil the criteria of ever-smokers, they currently smoke regularly, but on a nondaily basis (NCHS 2017). Of note, intermittent smoking is a commonly used synonym referring to occasional smoking (Shiffman 2009).

Considering smoking cessation, Ockene and colleagues recommended in 2000 that the standard terms used should be the following: quit attempts, successful change, lapse, relapse, recycling, short-term maintenance, and long-term maintenance (Ockene et al. 2000). Successful change as a process from daily to ex-smoking should therefore be the period from 7 days to <6 months of non-smoking maintenance. In addition, Ockene recommended that short-term successful maintenance covers a non-smoking period from 6 to 12 months, and that 12 months can be applied as a cut-off point for long-term non-smoking maintenance. Recently, West recommended short-term abstinence to be the period from 4 weeks since cessation to 6 or even 12 months (West 2017). Further, long-term abstinence would then start at 6 or 12 months post-cessation.

In past decades especially, never smokers and former smokers could be pooled into the same group (Ramström 1988), and althought this can sometimes be seen even nowadays, it is not considered accurate since those people differ in terms of lifetime exposure, health behaviours (Noble et al. 2015), and health consequences, such as mortality (Carter et al. 2015). Sometimes occasional smokers are pooled with light daily smokers, justified by the fact that the CPD of occasional smokers may be more similar with light daily smokers than the CPD of light daily smokers with heavy daily smokers. In addition, the risk of CVD is nearly similar for occasional and daily smokers (Schane, Ling & Glantz 2010). Further, all-cause mortality has been reported to be similar among male occasional and light daily smokers.

2.1.4 Nicotine dependence

Tobacco smoking, mainly explained by nicotine dependence, is one of the leading causes of preventable death (Benowitz 1988, Mokdad et al. 2004, WHO 2009, USDHHS 2014).

Nicotine dependence is a chronic relapsing disorder (Shiffman 2006) and the main contributor for tobacco dependence (Benowitz 1988), which is recognised as a chronic disease [International Classification of diseases (ICD-10) F17.2 Mental and behavioural disorders due to use of tobacco: dependence syndrome (WHO 2016); Diagnostic and Statistical Manual of Mental Disorders (DSM-5) 305.1 Tobacco Use Disorder (American Psychiatric Association (APA) 2013)]. About half of daily smokers are nicotine dependent according to DSM/ICD dependence criteria (Hughes, Helzer & Lindberg 2006). Nicotine dependence is characterised by a clustering of behavioural, cognitive, and physiological phenomena developing after repeated nicotine use (Hughes, Higgins & Bickel 1994, Shiffman 2006, Benowitz 2010, WHO 2016). In order to become nicotine dependent, exposure to nicotine has to exist. Nicotine dependence typically includes a strong craving to take nicotine, difficulties in controlling nicotine use, persistence of nicotine use despite harmful consequences, a higher priority given to nicotine use than to other activities and obligations, increased tolerance, and sometimes a physical withdrawal state. Nicotine dependence is quite heritable, with heritability estimates varying from 40% to 75% depending on the population (Kaprio & Korhonen 2017).

To note, addiction and dependence are interchangeably used, and no consensus on the definitions and distinction between the terms exists (West & Hardy 2006). It has been suggested that addiction should be the term used to describe a syndrome involving a behaviour and feelings (i.e., psychological dependence), while dependence should be used to describe a physical dimension of this phenomenon. However, in this thesis summary, the same term used in the original study is mainly used. Nicotine addiction is a complex phenomenon involving physiological, psychological, behavioural and cultural factors (Heishman 1999).

To avoid withdrawal symptoms, smokers tend to smoke that amount of cigarettes which maintains near-complete saturation of certain nicotine binding receptors, thus causing desensitisation (Wang & Sun 2005, Benowitz 2010). Nicotine dependent smokers trying to avoid smoking often relapse when smoking-related cues emerge (Benowitz 2010). In addition, craving to smoke is partly maintained by the effect of those cues.

The most commonly used tool to measure nicotine dependence is the Fagerström Test for Nicotine Dependence (FTND) (Fagerström 1978, Heatherton et al. 1991). However, no gold standard to measure nicotine dependence exists, and other measures are also applied (Shiffman et al. 2012a). For example, nicotine dependence can be indirectly measured by CPD (West & Hardy 2006). The more nicotine dependent smokers tend to smoke more cigarettes than those with lower nicotine dependence. While the direct way to measure nicotine dependence, FTND, measures nicotine dependence quantitatively (Heatherton et al. 1991), two diagnostic assessments, ICD-10 and DSM-5, assess tobacco dependence qualitatively (i.e., fulfilling the criteria of diagnosis or not) (APA 2013, WHO 2016). Further, DSM-5, classifies tobacco dependence into three classes according to the severity of tobacco dependence, while ICD-10 does not.

The FTND sum score ranges from 0 to 10 (Heatherton et al. 1991). Subjects scoring zero to three points are considered to have mild, four to six moderate, and seven to ten severe nicotine dependence (Fagerström et al. 2012). The items and scoring of the FTND are presented in Table 4. The FTND was developed from the Fagerström Tolerance Questionnaire (FTQ) (Fagerström 1978, Heatherton et al. 1991). The FTQ was created in 1978 (Fagerström 1978) and revised in 1991 to comprise six out of the eight original items (Heatherton et al. 1991). The development was done to correct the FTQ's psychometric and conceptual problems (Heatherton et al. 1991). The items regarding nicotine rating and inhalation were eliminated because they only added little to the measurement and had methodical problems (Heatherton et al. 1991). In addition, when the FTND was developed, some of the items were re-scored and the maximum sum score decreased from 11 to 10 (Fagerström 1978, Heatherton et al. 1991). The FTND is a valid and reliable commonly used measurement to measure the physical traits of nicotine dependence in clinical and research settings (Pomerleau et al. 1994, Etter 2005, Svicher et al. 2018). Recently, the name of the test was revised to the Fagerström Test for Cigarette Dependence (FTCD) (Fagerström 2012). Although this revision is adequate, since the test measures cigarette dependence rather than nicotine dependence, it has not been used widely. Instead, FTND is still mainly applied to refer to the scale. Because the abbreviation FTND was used in previously published Studies II and IV, for congruity, FTND is used throughout the thesis.

In clinical settings especially, to measure nicotine dependence faster, health professionals use the Heaviness of Smoking Index (HSI), which is composed of FTND items one and four, with sum score ranges from zero to six (Heatherton et al. 1991, Svicher et al. 2018). The HSI is as accurate at predicting smoking cessation as FTND (Fagerström et al. 2012).

Table 4. *Items and scoring for the Fagerström Test for Nicotine Dependence (FTND) (Fagerström 1978, Heatherton et al. 1991).*

Items	Answers	Points
1. How soon after you wake up do you smoke your first cigarette?	Within 5 minutes	3
	6 – 30 minutes	2
	31 – 60 minutes	1
	After 60 minutes	0
2. Do you find it difficult to refrain from smoking in places where it is forbidden (e.g., in church, at the library, in cinema, etc.)?	Yes	1
	No	0
3. Which cigarette would you hate most to give up?	The first one in the morning	1
	All others	0
4. How many cigarettes/day do you smoke?	10 or less	0
	11 – 20	1
	21 – 30	2
	31 or more	3
5. Do you smoke more frequently during the first hours after waking than during the rest of the day?	Yes	1
	No	0
6. Do you smoke if you are so ill that you are in bed most of the day?	Yes	1
	No	0

2.1.5 Self-efficacy and motivation to quit

Theories behind self-efficacy and motivation to quit

Self-efficacy is a social construct, which has different definitions (West & Hardy 2006). In Bandura's widely-used social cognitive theory, self-efficacy refers to the confidence of an individual's own ability to successfully perform and sustain a certain behaviour in a given situation (Bandura 1977, Bandura 1997). The basis of Bandura's theory encompasses the following four aspects as summarised by West and Hardy (2006): one's self-efficacy level affects the goal that the person pursues, the effort level used to achieve such goals, the time the person will persevere in pursuit of their goals when facing obstacles, and the likelihood of such a goal to be achieved (West & Hardy 2006). Self-efficacy can refer to the general concept of capability, or to specific situations. Even when general self-efficacy is high, self-efficacy in specific situations can be low (Gwaltney et al. 2001). In this thesis, self-efficacy refers to a specific situation, self-efficacy to quit smoking.

Another widely-used theory to model behaviour change is the Theory of Planned Behaviour by Ajzen (Ajzen 1991). It is an extension of the Theory of Reasoned Action (Fishbein &

Ajzen 1975), and was developed to improve the modelling of behaviours in which people have incomplete volitional control (Ajzen 1991). In the Theory of Planned Behaviour, behaviour change is mediated via intention, which is affected by three tracks: 1) behavioural beliefs and attitudes towards the behaviour, 2) normative beliefs and subjective norms, and 3) control beliefs and perceived behavioural control (Ajzen 1991). The Theory of Planned Behaviour Model related to the self-efficacy and motivation to quit smoking is presented in Figure 1. The intention to perform a given volitionally-controlled behaviour plays a central role in behaviour change. The intention captures the factors of motivation, which then influence behaviour. Generally, the stronger the intention, the more likely it is that a person will try to change their behaviour. Simplified, motivation means the amount of effort people are willing to try.

Bandura's self-efficacy is quite similar to Ajzen's model concept of perceived behavioural control (Bandura 1977, Ajzen 1991, Ajzen 2002). Both theories refer to a perceived ability to perform a behaviour, not the perceived likelihood that performing the behaviour will produce a desired goal (Ajzen 2002). To make the concept of perceived behavioural control more clear, Ajzen later stated that it should be read as "perceived control over performance of a behaviour" (Ajzen 2002).

The Theory of Planned Behaviour can also be applied to depict the role of motivation as a predictor of certain behaviours (Ajzen 1991). The main idea behind it is that behavioural achievement depends jointly on motivation. In the model, self-efficacy (perceived behavioural control) to quit smoking affects the motivation to quit (intention), which then affects smoking cessation (behaviour) (Ajzen 1991), as shown in Figure 1. Thus, self-efficacy and motivation to quit are components involved in the smoking cessation process (West & Hardy 2006).

Both perceived behavioural control (including self-efficacy) and intention (including motivation) can be used directly to predict behavioural achievement (Ajzen 1991). The three following conditions have to exist for accurate prediction. First, intention and perceived behavioural control must be assessed in relation to the particular behaviour and in the same context in which the behaviour occurs. Secondly, intention and perceived behavioural control must remain stable in the interval between their assessment and observation of the behaviour. Thirdly, the measurement for perceived behavioural control has to be accurate. Thus, it is reasonable that the importance of both perceived behavioural control and intention as the predictor of smoking cessation varies according to different environments and the states of change.

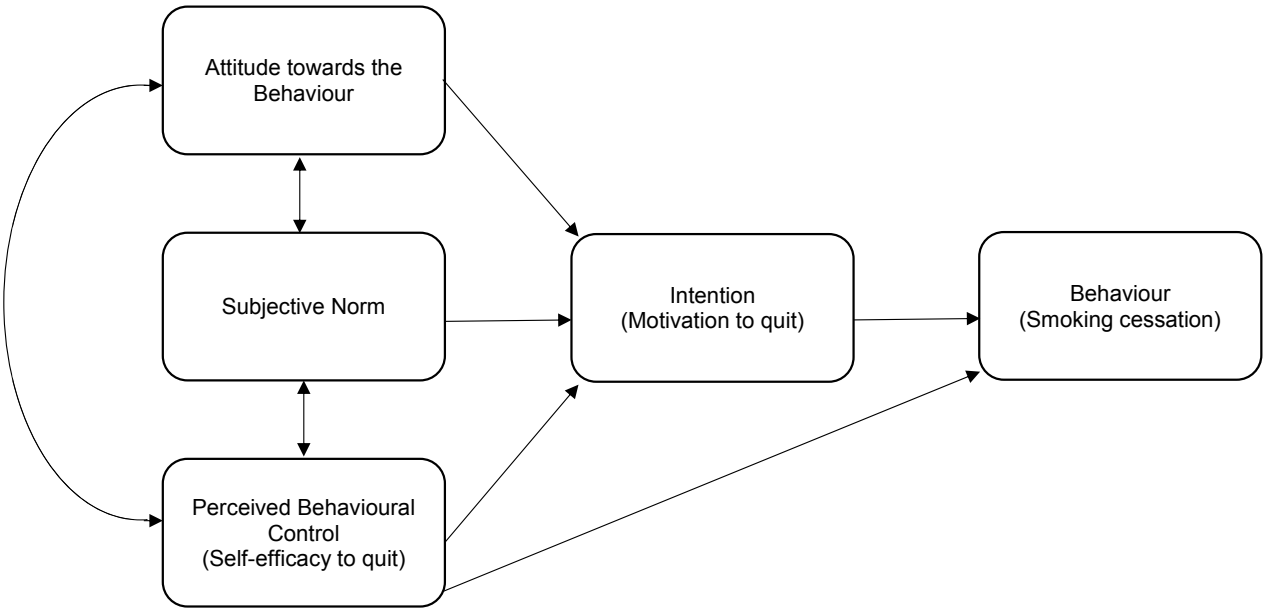

Figure 1. *Theory of Planned Behaviour Model related to smoking cessation. Modified from Ajzen (1991). Used with permission.*

Later, a more modern framework to model behaviour change, consisting of capability, opportunity, motivation and behaviour (the COM-B system), was established (Michie, van Stralen & West 2011). The COM-B system is formed of capability, opportunity, and motivation as the predictor of behaviour as shown in Figure 2. Capability refers to the individual's psychological and physical capacity to pursue a certain action, including having the knowledge and skills needed. Self-efficacy to quit smoking is included in the capability. Motivation refers to all processes that energise and direct behaviour, including habitual processes, emotional responding, and decision-making. Motivation to quit is a specific smoking-related form of motivation. Further, in the COM-B system, opportunity refers to all external factors affecting the behaviour either encouragingly or discouragingly. An example of this encouraging opportunity related to smoking cessation is support from a spouse (Coppotelli & Orleans 1985, Gulliver et al. 1995). In addition, an example of a discouraging factor is weight concerns.

The main differences in the COM-B system compared to the Theory of Planned Behaviour Model are the following. First, all three, capability (i.e., self-efficacy), motivation, and opportunity, affects equally and directly to the behaviour change. Whereas, in the Theory of Planned Behaviour Model, self-efficacy affects both directly and through motivation to behaviour change. Second, in the COM-B system model, influence is bidirectional, with behaviour itself also affecting capability, motivation and opportunity, while in the Theory of Planned Behaviour Model is only unidirectional. Hence, in this thesis the modelling of

self-efficacy and motivation to quit is based on the COM-B system model (Michie et al. 2011).

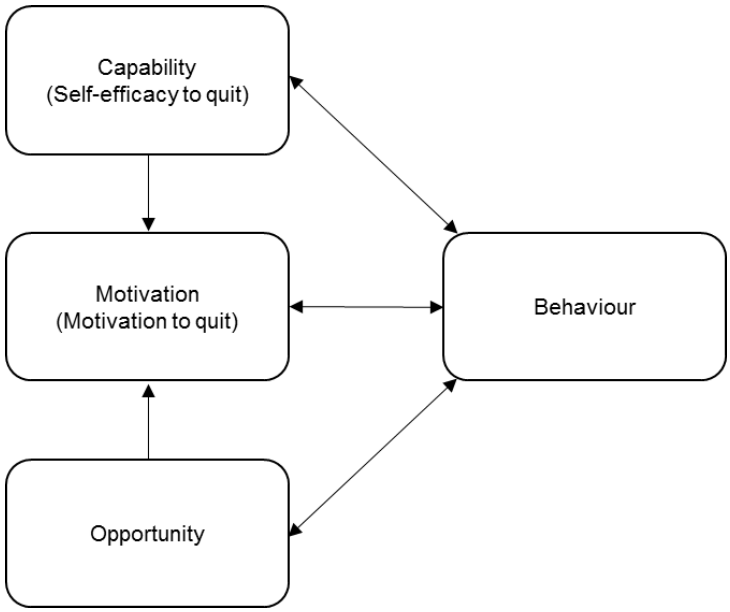

Figure 2. *COM-B system regarding smoking cessation. Modified from Michie et al. 2011. Used with permission.*

Self-efficacy to quit smoking and smoking cessation

In older studies, as Gwaltney and colleagues gathered together in their meta-analysis (2009), the predictive value of self-efficacy for smoking cessation depends on the timing of when self-efficacy is measured, and the population studied (Gwaltney et al. 2009). When self-efficacy is measured prior to a quit attempt, it has only a modest role in predicting subsequent smoking status, accounting for about 2% of the variance in smoking status. The predictive value is stronger when self-efficacy is assessed post-quit. In addition, Gwaltney and colleagues concluded that self-efficacy should be measured and strengthened not just before the quit, but during the entire cessation process.

In a review including adult general populations by Vangeli and colleagues (2011), self-efficacy predicted smoking cessation inconsistently; self-efficacy was a predictor in two studies, but no association was found in four other studies included in the review. Further, in Ockene and colleagues' (2000) review including both treated and untreated adult smokers, self-efficacy predicted successful smoking cessation in both groups.

Further, in one randomised controlled trial (RCT) focusing on women smokers, self-efficacy did not differ by different intervention groups, and thus did not predict smoking

cessation (Spring et al. 2004). In contrast, in a web-based cessation program with motivated quitters, baseline self-efficacy was the main predictor for successful cessation at 6-weeks post-cessation (Smit et al. 2014). However, rather contradictory to Gwaltney and colleagues' meta-analysis, baseline self-efficacy predicted smoking cessation in a population-based study with a follow-up as far as three years from the baseline (Lindberg et al. 2015). However, they do not specify the amount of self-efficacy accounting for smoking cessation compared to the other predictors. Moreover, in a Chinese study with a clinical sample from a smoking cessation clinic, self-efficacy was not a strong predictor of smoking cessation at 26-weeks post-cessation (Ho et al. 2015).

Self-efficacy to quit can be assessed by one or multiple items (Gwaltney et al. 2009). The assessing with multiple items does not predict smoking cessation any better than single item assessment, and may even predict it worse. To maximise the predictive validity, self-efficacy should be measured after the quit attempt has begun. The conclusions in Gwaltney and colleagues' meta-analysis were in line with the Theory of planned behaviour and could be seen in the study by Smit and colleagues (2014); the level of self-efficacy varies over time and predicts proximal behaviour better than distal behaviour (Gwaltney et al. 2009). To conclude, self-efficacy is a predictor for smoking cessation, however, it covers only a small amount of the variation of the subsequent smoking status.

Motivation to quit smoking and smoking cessation

Another component involved in the smoking cessation process, motivation to quit, has only a modest value as a predictor of smoking cessation. In Vangeli and colleagues' review of adult general populations, motivation to quit had no association with smoking cessation in three studies, while in one, motivation to quit predicted a worse smoking cessation rate (Vangeli et al. 2011). Caponneto and Polosa conclude in their review (2008), which is directed toward clinical practice, that accumulating evidence indicates that motivation level can predict successful smoking cessation. Further, in Ockene and colleagues' (2000) review, motivation to quit predicts smoking cessation only in untreated adult smokers. Motivation to quit can be measured with one or multiple items (Caponnetto & Polosa 2008, Vangeli et al. 2011).

2.1.6 Smoking cessation

Smoking cessation is a process characterised by quit attempts, abstinence periods, lapses, relapses, re-attempts, and successful cessation (Killeen 2011, West 2017). A consensus about the definition of a quit attempt does exist. A quit attempt is defined as a try to quit smoking with an abstinence period of at least 24 hours (Ockene et al. 2000). A lapse is defined as smoking a few cigarettes during a quit attempt but then returning to being abstinent, whereas a relapse is defined as resuming one's regular smoking patterns after a quit attempt (West 2017).

Thus, due to the nature of the cessation process, short-term abstinence covers the phase from 4 weeks since abstinence until 6 or even 12 months, whereas long-term abstinence starts after 6 or even 12 months of abstinence (West 2017). So, for a person who has successfully quit smoking to be counted as an ex-smoker, the time since their last smoked cigarette is as far as 6, or even 12, months (Ockene et al. 2000). During that time, people have stabilised their non-smoking habit, with the highest risk for relapse far behind them (Hughes, Keely & Naud 2004). The highest risk for relapsing being within the first two weeks after cessation, with withdrawal symptoms also being strongest during this time. Withdrawal symptoms emerge 6 to 12 hours post-cessation, are strongest at 1 to 3 days, and last 3 to 4 weeks on average (Hughes et al. 1994).

About 40% of daily smokers make repeated quit attempts in a given year (Borland et al. 2012). The estimate for unaided abstinence rates for 6 to 12 months varies from 3% to 5% in a given year (Hughes et al. 2004). Successful cessation may demand from 3 to even 142 cessation attempts (Curry & McBride 1994, Chaiton et al. 2016). The major negative predictor for successful smoking cessation is nicotine dependence (Vangeli et al. 2011). In contrast, higher age (Vangeli et al. 2011) and support from a spouse (Coppotelli & Orleans 1985, Gulliver et al. 1995) predict successful smoking cessation. The results of studies examining gender, marital status, socioeconomic status, self-efficacy to quit, and motivation to quit as predictors of smoking cessation are mixed (Vangeli et al. 2011, West et al. 2018, Dorner et al. 2011, Pennanen et al. 2014).

Smoking cessation interventions with a comprehensive approach involving behavioural support and pharmacotherapy increase abstinence rates (Zwar, Mendelsohn & Richmond 2014). Cessation support from doctors and other health professionals is vital. Effective medicines include varenicline, nicotine replacement therapy, bupropion, cytisine, and nortriptyline (Tobacco dependence and cessation. Current Care Guidelines 2012, Cahill et al. 2013).

2.2 Smoking and weight concerns

2.2.1 Prevalence and gender differences

The overall prevalence of smoking-specific weight concerns is 21–80%, depending on the study (Meyers et al. 1997, Jeffery et al. 2000, Clark et al. 2006, Pomerleau & Snedecor 2008, Pankova et al. 2016). The prevalence according to gender is 9–62% among men and 30–86% among women (Meyers et al. 1997, Jeffery et al. 2000, Pomerleau, Zucker & Stewart 2001, Clark et al. 2006, Pomerleau & Snedecor 2008, Pankova et al. 2016). Hence, women consistently report a higher prevalence of weight concerns than men (Jeffery et al. 2000, Pomerleau & Snedecor 2008, Meyers et al. 1997, Clark et al. 2006, Pankova et al. 2016). The prevalences among both genders and combined are shown in Table 5.

Only a few findings have been reported regarding the weight concerns according to smoking status. A review by French and Jeffery concludes that current daily smokers have the highest levels of smoking-specific weight concerns (French & Jeffery 1995).

Table 5. *The prevalence of weight concerns among daily smokers.*

	Prevalence (%)		
First author year	Among men	Among women	Total
Meyers 1997	22	47	39
Jeffery 2000	62	86	80
Pomerleau 2001	-	67	-
Clark 2006	26	50	40
Pomerleau 2008	9	30	21
Pánková 2016	19	50	34

The prevalence of general weight concerns has varied from 52% to 60% (Cooper et al. 2006, Pisinger, Jorgensen 2007b, Landrau-Cribbs et al. 2015). In a review by French and Jeffery, general weight concerns did not differ by smoking status (French & Jeffery 1995), while in the Inter99 study, daily smokers had less general weight concerns than never smokers (Pisinger, Jorgensen 2007b). The prevalences among both genders and combined are shown in Table 6.

Table 6. *The prevalence of general weight concerns among daily smokers.*

	Prevalence (%)		
First author year	Among men	Among women	Total
Cooper 2006	-	-	54
Pisinger 2007	42	61	52
Landrau-Cribbs 2015	-	-	60

2.2.2 Association with smoking initiation

In Finland, smoking initiation occurs mainly in adolescence (Kinnunen et al. 2017). Although the focus of this thesis is on adults, an exception is made here to discuss this age range because of the nature of the phenomenon. Weigh concerns and smoking initiation have a positive association among adolescents as shown in reviews by French and Jeffery

(1995), Potter and colleagues (2003), and a Report from the Surgeon General (2012) (USDHHS 2012). However, in Potter and colleagues' review, the association differed depending on the measured dimension of weight concerns. The strongest evidence was for dieting behaviours. In addition, girls initiate smoking for the purpose of weight control more than boys (Potter et al. 2004, USDHHS 2012). Further, this association is also positive in a more recent Dutch study with 13–16 year old adolescents (Harakeh et al. 2010).

Cigarette companies have promoted smoking as a tool for weight controlling since the 1920s (USDHHS 2012). During the 1920s, smoking among women was rare and cigarette companies wanted to reach a new target group to increase tobacco sales. Previously, before the major prohibitions of tobacco marketing, advertising was more straightforward. Later, young models were depicted to promote slim smoking. Nowadays, the approach applied is mostly occurring on the internet, especially social media, in a more indirect way.

2.2.3 Association with nicotine dependence

Weight concerns have a positive association with nicotine dependence in both population and trial settings. In the multi-national longitudinal ATTEMPT cohort study, baseline weight concerns with sum scores ≥5 (Borrelli Scale) were positively associated with the continuous FTND sum score but not with the amount of smoking, CPD ≥20 (proxy for nicotine dependence) (Aubin et al. 2009). Very-weight-concerned participants had higher FTND mean scores than somewhat-concerned or not-concerned ones in a national survey of women smokers in the USA (Pomerleau et al. 2001). Further, very-weight-concerned women smoked more CPD than somewhat-concerned or not-concerned women. In an RCT for a worksite smoking cessation intervention, weight concerns were positively associated with FTND (Jeffery et al. 2000). Conversely, in an RCT focusing on different treatments of post-cessation weight gain concerns, weight-concerned women did not have elevated nicotine dependency, as measured by FTND (Levine, Perkins & Marcus 2001). However, a recent mini-review about weight concerns as a barrier to smoking cessation confirms the positive associations between weight concerns and nicotine dependence and also between weight concerns and CPD (Germeroth & Levine 2018).

2.2.4 Association with self-efficacy and motivation to quit

The literature on associations between weight concerns and self-efficacy to quit is generally in agreement regarding the results. In three RCTs, weight concerns were inversely associated with self-efficacy to quit (Bowen et al. 2000, Jeffery et al. 2000, Sepinwall & Borrelli 2004). In one of the studies not controlling for the untreated group, self-efficacy was assessed with as many as nine items pre-cessation, and the inverse association between weight concerns and self-efficacy was seen in both genders (Jeffery et al. 2000). In the other clinical double-blind RCT restricted to women with a similar finding, pre-cessation weight concerns accounted for 4% of the variance in self-efficacy to quit (Bowen et al. 2000). An

additional similar finding, the inverse association between weight concerns and self-efficacy was presented in an RCT of smoking cessation intervention conducted by home healthcare nurses on their medically ill smoker patients (Sepinwall & Borrelli 2004). Additionally, again, in a clinic-based cessation study without randomisation, weight concerns were inversely associated with self-efficacy to quit (Borrelli & Mermelstein 1998). Further, weight concerns were also inversely associated with self-efficacy in studies with weaker methodology. This was shown in a low-intensity smoking cessation study among young women (Glasgow et al. 1999) and in a study conducted among smokers with substance use disorders attending a residential substance treatment (Martin et al. 2016).

The findings on associations between weight concerns and motivation to quit are rather inconsistent. A review about smoking cessation in peri- and postmenopausal women concludes that weight concerns may contribute to reduced motivation to quit smoking (McVay & Copeland 2011). Three RCTs demonstrated controversial findings however (Clark et al. 2004, Sepinwall & Borrelli 2004, McKee et al. 2005,). In a double-blind, placebo-controlled smoking cessation RCT focusing on men, weight concerns were inversely associated with motivation to quit (Clark et al. 2004). Whereas, in a smoking cessation RCT addressing gender differences, weight concerns were inversely associated with pre-treatment motivation to quit in women, but no association was found in men (McKee et al. 2005). This may reflect the higher importance of weight concerns in women. In contrast, higher weight concerns were associated with higher motivation to quit in a smoking cessation RCT conducted by home healthcare nurses on their medically ill smoker patients (Sepinwall & Borrelli 2004).

2.2.5 Association with smoking cessation

Smoking-specific weight concerns

A literature review on weight concerns and smoking by French and Jeffery (1995) concludes that smoking-specific weight concerns may negatively affect on smoking cessation. Only one of the included studies demonstrated results from a population-based sample with measurements of both smoking-specific and general weight concerns (French et al. 1995). In both genders, dieting, perceived overweightness or being at one's preferred weight was not related to cessation at 2-years follow-up. Among women, previous participation in a weight control program increased the likelihood of cessation. In addition, in two of the methodologically strongest studies, weight concerns did not predict cessation or relapse consistently (French et al. 1992, French et al. 1995). However, in two smaller intervention studies, weight concerns did predict smoking cessation (Klesges et al. 1988, French & Jeffery 1995).

Another recent review focusing on smoking cessation in peri- and postmenopausal women concludes that weight concerns may contribute to smoking relapse after a quit attempt (McVay & Copeland 2011). This may be the case especially for peri- and postmenopausal

women because they are quite prone to gain weight due to ageing (Davis et al. 2012) and during the smoking cessation process (McVay & Copeland 2011).

In Germeroth and Levine's recent mini-review (2018), which is, unfortunately, limited to post-cessation weight concerns as a barrier to smoking cessation, the relationship between weight concerns and smoking cessation is mixed. In one of the seven studies included to the review, higher weight concerns predicted lower abstinence at 7-days and 7-months post-cessation (Schauer et al. 2013), while in another study, higher weight concerns predicted higher abstinence at 1-month (Baha, Le Faou 2013). Further, four included studies did not find any association (Faseru et al. 2013, Landrau-Cribbs et al. 2015, Martin et al. 2016, Pankova et al. 2016). The last included study assessed weight control by smoking rather than actual weight concerns, and the outcome was not smoking cessation, but making a past-year quit attempt (Strong et al. 2014). However, in this study, weight control was associated with a lower odds of making a past-year quit attempt.

In the following paragraphs, I outline the main findings regarding weight concerns as a predictor of smoking cessation according to the applied weight concerns measures. The main focus is on the studies published beyond the coverage of French and Jeffery's (1995), McVay and Copeland's (2011), and Germeroth and Levine's (2018) reviews. A summary of the articles assessing smoking-specific weight concerns–smoking cessation associations are presented in Table 7.

In Meyers and colleagues' prospective community-based smoking cessation intervention study, weight-concerned daily smokers were less likely to be abstinent post-treatment, and at the 1-, 6-, and 12-month follow-ups (Meyers et al. 1997). Later, applying the same questions, the following results have been published. In a smoking cessation RCT, non-weight-concerned smokers were more often abstinent at 12-weeks post study entrance compared to weight-concerned participants (Clark et al. 2006). Whereas, in a recent study of a tobacco dependence treatment program in the Czech Republic, weight concerns were not associated with continuous abstinence at 12 months (Pankova et al. 2016).

Weight concerns did not predict smoking cessation in Borrelli and Mermelstein's clinic-based cessation program study (Borrelli & Mermelstein 1998). They assessed weight concerns with their Weight Concern Scale, which has later been used several times. By applying their scale, weight concerns have mainly been measured in non-population-based settings. Likewise, by applying this scale, weight concerns were not associated with relapse in the multinational ATTEMPT cohort study with 18-months of follow-up (Zhou et al. 2009).

Jeffery and colleagues created a two-question assessment to examine weight concerns in a worksite smoking cessation RCT (Jeffery et al. 2000). In women, weight concerns predicted abstinence in a treatment controlled model at 12-months follow-up. When further controlled for demographics, social influences, and FTND, the association was no longer statistically significant. In men, weight concerns did not predict smoking cessation.

Also, Perkins and colleagues created a two-question assessment for weight concerns. When applying it, abstinence rates between non-weight-concerned and weight-concerned women did not differ in a smoking intervention RCT with cognitive-behavioural therapy (Perkins et al. 2001). Since then, the same scale has been applied multiple times with diverse settings, such as a double-blind, placebo-controlled RCT with bupropion and cognitive-behavioural therapy as the treatment for smoking cessation (Levine et al. 2010).

When weight concerns were measured with the Smoking Situations Questionnaire (SSQ) created by Weekley and colleagues (1992), they were not predictive of abstinence in a RCT for behavioural smoking and weight control treatment in female smokers with 9-months follow-up (Spring et al. 2004). In addition, weight concerns were not predictive for abstinence at 6 months in female smokers in a low-intensity smoking cessation intervention study (Glasgow et al. 1999).

Smoking-specific weight concerns have also been examined in restricted groups. Weight concerns did not predict smoking cessation in veterans at the end of a 2-week smoking cessation program nor at 1-month follow-up (Cooper et al. 2006), in the homeless at 8 weeks or 26 weeks follow-ups (Pinsker et al. 2017), nor in substance-dependent patients at 1- or 3-month post-cessation (Martin et al. 2016).

To summarise, the findings regarding smoking-specific weight concerns as a predictor of smoking cessation are mixed. This discrepancy is partly explained by diverse weight concern measures, diverse statistical methods, and diverse covariates applied for controlling the robustness of the association (Germeroth & Levine 2018).

Table 7. *Summary of articles assessing the smoking-specific weight concerns–smoking cessation associations.*

First author year	Countries N % women Population	Design	Weight concerns measures	Smoking outcomes	Statistical method	Adjustments	Main results
Jeffery 1997	USA 242 34% women Participants from randomised intervention study for modifying multiple risk factors for cardiovascular disease	Workplace cohort, with 24 months follow-up	one smoking-specific question	cessation, quit attempts, plan to quit	logistic regression	age, gender, education, treatment group (intervention vs. control), BMI	Weight concerns did not predict quitting or quit attempts
Meyers 1997	USA 580 63% women Participants from smoking cessation intervention	12-month community-based smoking cessation intervention	smoking-specific, dichotomy: non-weight-concerned/weight-concerned	abstinence	logistic regression	gender	non-weight-concerned participants were more likely to quit at 1 month (OR=1.89, p=0.024), end of the treatment (7 weeks) (OR=1.56, p=0.043), 6 months (OR=1.86,

							p=0.068), and 12 months (OR=2.13, p=0.46).
Perkins 1997	USA 219 100% women	group smoking cessation counselling treatment RCT	smoking-specific, general	self-reported point-prevalence abstinence with confirmation by expired-air CO at end of treatment, 4 weeks and 3, 6, 12-months post-cessation	logistic regression	treatment group	abstinence rates between non-weight-concerned and weight-concerned did not differ
Borrelli 1998	USA 122 66% women Participants from smoking cessation intervention	3-month smoking cessation intervention	smoking-specific Borrelli Scale: weight concerns and confidence to prevent weight gain	abstinence	hierarchical logistic regression	baseline smoking rate, BMI, gender, weight efficacy	weight concerns did not predict smoking status at week 7 or week 18. Confidence to prevent weight gain did not predict smoking status.
Glasgow 1999	USA 506 100% women	prospective intervention study	smoking-specific SSQ scale	quit attempt, cessation,	logistic regression	age, education, years with	weight concerns did not predict quit

	Smokers attending Planned Parenthood clinics			reducing of CPD, self-efficacy for stopping smoking		Planned Parenthood, smoking rate, dependence composite, self-efficacy to quit, stage of change	attempt, cessation, reducing of CPD, or change in self-efficacy for stopping smoking
Jeffery 2000	USA 2106 55% women	randomised worksite smoking cessation intervention trial 12-months follow-up	smoking-specific, general	self-reported abstinence at FU	logistic regression	treatment group, age, gender, treatment group, FTND, social influence variables	weight concerns did not predict quitting
Clark 2006	USA 1692 60% women Participants from 12-week smoking cessation intervention	12-week prospective RCT	smoking-specific, Meyers scale dichotomy	abstinence	logistic regression	age, race, marital status, FTND, treatment condition, treatment location	weight concerns predicted worse abstinence rates in total sample (OR=1.28, p=0.06) but not for genders separately, or according to weight concerns and treatment group simultaneously
Spring 2004	USA 315	16-week RCT	smoking-specific weight concern	self-reported	logistic regression	baseline weight, FTQ,	weight concerns did

	100% women Participants from behavioural smoking treatment intervention	with 9 months follow-up	scale by Weekley (1992)	7-day point prevalence with expired CO confirmation treatment at visits 7–16 and 4, 5, 6, 7, 8, 9 months post-treatment follow-up		time to dropout, attendance percentage, percentage of smoking status data missing prior to dropout, weight change	not predict abstinence
Cooper 2006	USA 63 40% women Veterans from QuitSmartk tobacco cessation program	2-week smoking cessation program with 1-month follow-up	smoking-specific questions similar to Meyers (1997), general weight concerns	self-report smoking status with CO verification at orientation, at post-program, at 1-month follow-up.	logistic regression	cessation-related weight concerns, general weight concerns	cessation-related weight concerns did not predict smoking status (post-program p =.076; 1-month follow-up p =.143). General weight concerns predicted quit status at post-program, those with general weight concerns were 5.4 times more likely to quit, p =.011), and at

							the 1-month follow-up, 4.3 times more likely to quit (p =.027).
Zhou 2009	Canada, France, Spain, UK, USA 2431 45% women Participants from online research study ATTEMPT	18-month follow-up online research study	smoking-specific Borrelli Scale: weight concerns and confidence to prevent weight gain	quit attempt and relapse	discrete time survival analysis	country, age, gender, education, household income level, marital status, employment status, motivational status, past quitting history, FTND, nicotine cue, BMI, confidence to prevent weight gain, health-related factors, change in smoking consumption, smoking cessation aids, desire/craving to smoke, mood disturbance,	weight concerns did not predict quit attempt (OR=1.02; CI 0.95, 1.11) or relapse (OR=1.12; CI 0.98, 1.28). Confidence to prevent weight gain did not predict quit attempt (OR=1.06; CI 0.98, 1.15) or relapse (OR=1.01; CI 0.89, 1.15).

						sleep disturbance, increased appetite, hunger or weight gain and weight change before the quit attempt	
Baha 2013	France 5165 59% women light smokers attending French smoking cessation services	retrospectively	one smoking-specific question	7-day point prevalence abstinence at 1 month	stepwise multivariate logistic regression models	gender, age, not specified baseline covariates, NRT	higher weight concerns were associated with higher 1-month abstinence rates among men (OR=1.45; CI 1.06, 1.99).
Faseru 2013	USA 540 66% women African-American light smokers from smoking cessation intervention with bupropion	placebo-controlled RCT of bupropion	smoking-specific Borrelli Scale: weight concerns and confidence to prevent weight gain	cotinine-verified 7-day point prevalence abstinence at the end treatment (week 7) and at week 26	multiple logistic regression analyses	treatment bupropion vs placebo, years smoked, visit attendance, cotinine level, BMI	weight concerns did not predict smoking cessation.
Schauer 2013	USA 242 68% women Smoker callers to the	prospective telephone-based follow-up survey	not specified (“level of concern about gaining weight”); dichotomy	self-reported 7-day point prevalence	multiple logistic regression	gender, age, BMI, diabetes, NRT use, mean	weight-concerned participants less likely to be abstinent

	Washington State Tobacco Quit Line		(≥5 vs <5, on a 10-point scale)	7 days post-cessation, 30-day point prevalence at 7 months		depression score	(7-day OR=0.8; CI 0.65, 0.88; 30-day OR=0.8; CI 0.67, 0.91).
Landrau-Cribbs 2015	USA 354 49% women Hispanic participants from brief smoking cessation intervention	RCT of a brief smoking cessation intervention	smoking-specific (similar to Meyers et al. 1997 questions) and general	30-day point prevalence at 3 months	multiple hierarchical logistic regressions	intervention condition, age, gender, stage of change, cigarettes per month, smoking status (daily vs. non-daily, weight, general weight concerns, cessation-related weight concerns	weight concerns did not predict smoking cessation (OR=3.06; CI 0.56, 16.65).
Pánková, 2016	Czech Republic 593 50% women Patients at the Centre for Tobacco-Dependent in Prague	individual smoking treatment follow-up at 12 months	smoking-specific questions by Meyers et al. (1997)	continuous self-reported abstinence with expired air CO confirmation at 12 months	logistic regression, proportional hazards regression	baseline smoking rate, gender	no significant difference in percentage of abstinence at 12 months between non-weight-concerned and weight-concerned
Pinsker 2017	USA 430 25% women	8-week smoking cessation	Weight Concern Scale by Borrelli and Mermelstein	self-reported	logistic regression	treatment group,	cessation-related weight concerns did

	Homeless individuals participating in a smoking cessation intervention RCT	intervention, follow-up 26 weeks	(1998)	7-day point prevalence abstinence with CO verification		separate analyses by gender	not predict smoking status at week 8 or week 26

BMI=body mass index, CI=95% confidence interval, CO=carbon monoxide, CPD=cigarettes per day, FTND=Fagerström Test for Nicotine Dependence scale, FTQ=Fagerström Tolerance Questionnaire, NRT=Nicotine replacement therapy, OR=odds ratio, RCT= Randomized controlled trial, SSQ= Smoking situations questionnaire

General weight concerns

General weight concerns have also been examined as a predictor of smoking status. General weight concerns mainly do not predict smoking cessation. The previously mentioned literature review by French and Jeffery (1995) concludes that general weight concerns do not hinder smoking cessation. This conclusion was drawn based on two prospective and five cross-sectional studies, hence, the conclusion was only suggestive. In one prospective study, weight concerns did not predict smoking cessation in female smokers participating in smoking cessation (French et al. 1992). Likewise, weight concerns did not predict smoking cessation in another worksite intervention for smoking cessation and weigh loss (French et al. 1995).

The result was similar in the Danish population-based lifestyle intervention study, Inter99, where weight concerns did not predict abstinence at 1-year follow-up (Pisinger, Jorgensen 2007b). This may be because they measured weight concerns with a four-category variable, which may have reduced the power compared to a continuous predictor variable. General weight concerns also did not predict smoking cessation at 3-months follow-up in a brief smoking cessation intervention of Hispanic light daily and occasional smokers (Landrau-Cribbs et al. 2015). They applied a dichotomous non-weight-concerned/weight-concerned predictor and measured general weight concerns with a single straight question. In addition, smoking-specific weight concerns also did not predict cessation.

General weight concerns predicted a higher likelihood to quit smoking at post-program and 1-month follow-up in veterans in a tobacco cessation program (Cooper et al. 2006). Veterans are a quite specific group, so it may be argued that results about them are not that generalisable. However, generalisation is improved by the characteristics of the sample. About 60% of participants were men, 86% Caucasians, and the average age was 53 years, hence, their characteristics are quite similar to data applied in this thesis.

Recurrent dieting can be seen as an indicator for general weight concerns. In a Finnish cross-sectional study, among women, both daily smokers and ex-smokers were more likely to have recurrently dieted when compared to never smokers (Saarni et al. 2007). Furthermore, among men, daily smokers were less likely while ex-smokers were more likely to have recurrently dieted.

2.2.6 Association with weight

A recent mini review about post-cessation weight concerns as a barrier to smoking cessation generally found that weight concerns are highest among overweight or obese women and lowest among underweight women (Germeroth & Levine 2018). Only one study, by Landrau-Cribbs and colleagues (2015), disagreed with this finding, showing that higher weight was associated with a lower odds of weight concerns. Their study only represented part of the current smokers, as it was composed of light and occasional smokers participating

in a smoking cessation intervention. Women tend to have more weight concerns (Meyers et al. 1997, Jeffery et al. 2000, Clark et al. 2006, Pomerleau & Snedecor 2008, Pankova et al. 2016), but they do not gain more weight during the cessation process compared to men (Tian et al. 2015).

Mean weight gain was similar for people with and without weight concerns as Aubin and colleagues (2012) conclude in a meta-analysis about cessation-related weight gain. In a systematic Cochrane review about interventions for preventing weight gain after smoking cessation, weight management education did not reduce weight gain at the end of treatment (6 or 12 months), while personalised weight management support reduced weight gain at 12 months cessation (Farley et al. 2012). Further, exercise interventions did not reduce weight gain at the end of treatment, nor did cessation medication reduce weight gain at 12 months cessation.

In a systematic review and meta-analysis by Spring and colleagues (2009) about behavioural interventions to promote smoking cessation and prevent weight gain, those who received treatment for both cessation and weight control showed less weight gain than those who received treatment for cessation only. However, this was only seen <3 months after cessation, while later, at >6 months post-cessation, the result was no longer statistically significant. In addition, the same trend was seen regarding smoking cessation, the odds of being abstinent <3 months after smoking cessation were higher for those who also received treatment for weight control, but likewise, the result was no longer statistically significant at >6 months.

2.3 Smoking, body weight, and obesity

2.3.1 The associations of smoking with weight, general obesity, and abdominal obesity

Associations with daily smoking

The relationships of smoking with weight, general obesity and abdominal obesity are complex. Two reviews conclude that current daily smokers tend to weigh less than never smokers (Berlin 2008, Chiolero et al. 2008,). In addition, this association was also shown more recently in population-based longitudinal designs among men with 10 to 18 years follow-up (Munafo, Tilling & Ben-Shlomo 2009), and in both men and women with 8 years follow-up (de Munter et al. 2015). Further, the finding that daily smokers tend to weigh less than never smokers do has been shown in population-based cross-sectional settings multiple times (Bamia et al. 2004, Akbartabartoori, Lean & Hankey 2005, Canoy et al. 2005, Pisinger, Toft & Jorgensen 2009).

Among current daily smokers, however, BMI has been found to increase with CPD in cross-sectional settings (Bamia et al. 2004, Chiolero et al. 2007, Pisinger et al. 2009, de Oliveira Fontes Gasperin et al. 2014). In addition, a recent study applying a Mendelian randomisation approach found that in observational analyses high tobacco consumption was associated with higher body weight among current daily smokers (Winslow, Rode & Nordestgaard 2015). They found that one cigarette per day was associated with a 0.05 kg higher body weight, and 0.02 kg/m^2 higher BMI. However, when a certain genotype (CHRNA3) was included in the analysis, the per-allele increase (CHRNA3 rs 1051730), together with high tobacco consumption, was associated with lower body weight.

Contradictory to BMI, daily smokers tend to have more abdominal obesity compared to never smokers, as Berlin concludes in a brief review (Berlin 2008). The review includes both waist circumference and WHR as indicators of abdominal obesity. Daily smokers tending to have more abdominal obesity compared to never smokers is also supported by a meta-analysis of 15 observational studies, although measurement for abdominal obesity was WHR only, not waist circumference (Shi et al. 2013). Mendelian randomisation meta-analysis is a method to show evidence for a causal relationship (Smith & Ebrahim 2003). A multinational Mendelian randomisation meta-analysis concludes that smoking may causally lead to the accumulation of fat in the abdominal area (i.e., abdominal obesity) (Morris et al. 2015).

However, by applying waist circumference as an indicator of abdominal obesity in a longitudinal setting, daily smokers had a lower increase in mean waist circumference than quitters at 1-year follow-up in the Inter99 study (Pisinger, Jorgensen 2007a). Again, by applying waist circumference as an indicator of abdominal obesity in cross-sectional settings, daily smokers had more abdominal obesity than never smokers in a population-based Danish study (Pisinger et al. 2009), in a population-based Dutch LifeLines cohort study (Slagter et al. 2013), and in a Chinese population-based study with almost half a million participants (Lv et al. 2015). However, a population-based Slovenian study confirmed this association only in men in the age group of 35-54 years, but found no association in women of 25-64 years nor in men in other age groups (Caks & Kos 2009).

Similar to BMI, both mean waist circumference (Clair et al. 2011) and WHR (Bamia et al. 2004, Pisinger et al. 2009) have been shown to increase according to CPD among daily smokers. In addition, mean waist circumferences have been shown to increase according to pack-years smoked (Clair et al. 2011, Kim et al. 2012).

Associations with smoking cessation

During smoking cessation, most quitters gain weight (Klesges et al. 1989, Aubin et al. 2012). Most of the weight gain occurs within the first six months post-cessation (Klesges et al. 1997, Aubin et al. 2012). In a systematic review and meta-analysis including 35 prospective cohort studies, an average weight gain for quitters was 4.1 kg, and BMI gain was 1.1 kg/ m^2 (Tian et al. 2015). In addition, when compared to continuing smokers,

quitting smoking was associated with an extra mean weight gain of 2.6 kg and mean BMI gain of 0.6 kg/m^2. Furthermore, in a meta-analysis including 62 smoking cessation trials, the mean weight gain was 1.1 kg at 1-month, 4.2 kg at 6-months and 4.7 kg at 12-months post-cessation in untreated quitters (Aubin et al. 2012). In addition, at 12-months post-cessation, 16% had lost weight and 13% had gained more than 10 kg.

Hence, weight gain variability among quitters is wide. Younger age, lower socio-economic status, obesity/underweightness, and heavier smoking are associated with higher post-cessation weight gain (Klesges et al. 1989, Filozof, Fernandez Pinilla & Fernandez-Cruz 2004, Lycett et al. 2011). However, being female (Tian et al. 2015) or having smoking-specific weight concerns are not associated with higher weight gain during cessation (Aubin et al. 2012).

Cessation-related weight gain is mostly due to increased body fat (Filozof et al. 2004, Audrain-McGovern & Benowitz 2011). In addition, genetic factors affect weight gain during the smoking cessation process.

Associations with former smoking

On average, ex-smokers are heavier than both never and daily smokers, as shown in a review comprised of 70 cross-sectional and longitudinal studies (Klesges et al. 1989). Ex-smokers being heavier than continuing daily smokers is also shown in more recent longitudinal studies (Pisinger, Jorgensen 2007a, Lycett et al. 2011). In cross-sectional settings, ex-smokers were heavier than never smokers and current daily smokers (Akbartabartoori et al. 2005, Canoy et al. 2005). In addition, ex-smokers have more abdominal obesity than never-smokers in both longitudinal (Pisinger, Jorgensen 2007a) and cross-sectional settings (Kwok et al. 2012, Sikorski et al. 2014, Lv et al. 2015). Further, ex-smokers have more abdominal obesity than daily smokers in cross-sectional settings (Kwok et al. 2012, Lv et al. 2015).

Associations with occasional smoking

In occasional smokers, findings regarding the associations of smoking with BMI and with abdominal obesity are scarcer. In a Chinese population-based study with a sample of half a million people, occasionally-smoking men had lower mean BMIs than never or ex-smokers, but higher BMIs than daily smokers (Lv et al. 2015). Whereas in women, occasional smokers had lower mean BMIs than daily and ex-smokers, but higher mean BMIs than never smokers.

The previously mentioned Chinese study also reported on the associations between smoking and abdominal obesity by gender (Lv et al. 2015). In men, daily smokers had lower mean waist circumferences compared to occasional smokers, while ex-smokers and never smokers had higher mean waist circumferences. Whereas in women, never smokers had

lower mean waist circumferences compared to occasional smokers, while ex-smokers and daily smokers had higher mean waist circumferences.

2.3.2 Health-related consequences of co-occurring smoking and obesity

Worldwide, smoking and obesity by themselves are known to be among the five leading preventable causes of morbidity and mortality (Benziger et al. 2016), but knowledge about the health-related consequences of co-occurring smoking and obesity is limited. In the Framingham Heart Study with more than 40 years follow-up, obese male and female smokers lost on average 14 and 13 years of life, respectively, compared to normal weight non-smokers (Peeters et al. 2003). Smoking by itself is harmful to almost all organs (US DHHS 2014). Normal-weight smokers lost about 10 years of life compared to never smokers (Doll et al. 2004, Pirie et al. 2013). In addition, smoking is the major risk factor for lung cancer (Danaei et al. 2009, Pirie et al. 2013, Lung cancer. Current Care Guidelines 2017). Further, smoking is a risk factor for various diseases, such as cardiovascular disease, diabetes, chronic obstructive pulmonary disease and multiple cancers (USDHHS 2014).

Combined smoking and obesity also increase the morbidity of various diseases. Smoking, general obesity, and abdominal obesity are major risk factors for metabolic diseases, such as type 2 diabetes and cardiovascular disease (Diabetes. Current Care Guidelines 2016). To give an example, the combination of smoking with obesity increases the risk of stroke (odds ratio (OR) =2.7; 95% Confidence Interval (CI) 1.1, 7.0) (Shinton 1997). Further, it has been shown that greater waist circumference is associated with higher lung cancer risk among current smokers than among never smokers (Hidayat et al. 2016). Current daily smokers with a waist circumference >98 cm had the highest incidence rate of coronary artery disease in the PRIME cohort study with 10 years follow-up (Chouraki et al. 2008). In addition, current daily smokers had higher coronary artery disease incidence rates regardless of waist circumference than never or ex-smokers.

2.3.3 Mechanisms underlying the associations of smoking with weight and obesity

Smoking, weight, and obesity

The molecular mechanisms behind reduced weight in daily smokers are complex and only partly known (Audrain-McGovern & Benowitz 2011). Most of smoking's effects on weight are mediated by nicotine. In addition, smoking itself may be used as a behavioural alternative to eating. Smoking reduces weight by increasing energy expenditure by ~10%, and by inhibiting the increase in compensatory caloric intake (Audrain-McGovern & Benowitz 2011, Harris, Zopey & Friedman 2016). Nicotine increases energy expenditure by direct effects on peripheral tissues, which are mostly mediated by catecholamines.

Nicotine increases the thermogenesis of brown adipose tissue and the utilization of fuel substrates. In addition, nicotine increases energy expenditure by indirect effects on neuroendocrine circuits in the central nervous system. Nicotine's effects in the hypothalamus suppress appetite, and this is one reason why smoking can serve as an alternative to eating.

Nicotine, as a general neurotransmitter-releasing agent, mainly acts through nicotinic acetylcholine receptors and increases the release of neurotransmitters (Filozof et al. 2004, Audrain-McGovern & Benowitz 2011). These include dopamine and serotonin, which reduce food intake. On the other hand, nicotine affects noradrenaline, which conversely stimulates food intake.

Some mechanisms underlying the associations between smoking and abdominal obesity have been established (Chiolero et al. 2008). Nicotine stimulates the sympathetic nervous system, which leads to higher plasma cortisol levels. Higher cortisol levels are associated with higher abdominal obesity. In addition, sex hormones may be involved. Among women, nicotine may reduce oestrogen and increase testosterone levels, which are associated with increased abdominal obesity. Nicotine may also reduce testosterone in men, which then may lead to higher abdominal obesity. In addition, nicotine impairs glucose tolerance, and insulin sensitivity, and increases insulin resistance (Filozof et al. 2004, Chiolero et al. 2008, Audrain-McGovern & Benowitz 2011, Harris et al. 2016). This is most likely due to the release of catecholamines such as noradrenaline and dopamine.

Weight gain during smoking cessation

Several mechanisms explain weight gain during the smoking cessation process. The main underlying mechanisms are increased energy intake, decreased resting metabolic rate, and changes in fatty acid catabolism (Filozof et al. 2004). The role of physical activity is uncertain, because it is controversial whether physical activity increases, decreases, or remains the same during the cessation process (Filozof et al. 2004, Audrain-McGovern & Benowitz 2011). The specific molecular mechanisms underlying weight gain during the cessation process are only partly known (Filozof et al. 2004, Audrain-McGovern & Benowitz 2011, Harris et al. 2016).

Several trajectories explain the increased energy intake after smoking cessation (Harris et al. 2016). The ability of nicotine as the suppressor of appetite may be reversed. Replacing rewards of nicotine with increased eating may occur. In addition, nicotine omission increases the satisfying value of food, especially those foods high in sugar and fat. Moreover, nicotine withdrawal causes an elevated reward threshold, leading to elevated eating to achieve satisfaction. Additionally, during the cessation process, ex-smokers cannot use smoking to control compulsive eating and overeating.

There are numerous identified neuropeptides and peptide hormones regulating food intake and weight that are affected by nicotine, as shown in Figure 3 (Filozof et al. 2004, Harris et

al. 2016). Adipose tissue secretes leptin, which is a negative regulator of food intake and a positive regulator of energy expenditure. Nicotine may affect the leptin biosynthesis and plasma concentrations. Further, neuropeptide Y is a potent stimulator of food intake, and nicotine may reduce the expression of neuropeptide Y. In addition, orexins are stimulators of food intake and nicotine may affect orexin levels. In addition, smoking cessation is associated with transient metabolic changes such as an increase in β cell insulin secretion, leading to increased glucose intake and eventually to fat accumulation in tissues.

Smoking cessation may lead to changes in the composition of the intestinal microbiota, which can partially explain cessation-related weight gain (Harris et al. 2016). During the cessation process, a shift in the composition of the intestinal microbiota has been observed. Additionally, microbial diversity increases. These observed changes are similar to differences in the gut microbiota composition between obese and lean people.

A reduced resting metabolic rate during cessation is reported by some studies (Filozof et al. 2004). The change in resting metabolic rate is estimated to explain nearly 40% of cessation-related weight gain. Reduced physical activity may explain a portion of weight gain during the cessation process in a sub-group of smokers, but physical activity has an opposite role for those smokers who increase their physical activity during their smoking cessation process (Filozof et al. 2004, Audrain-McGovern & Benowitz 2011).

Changes in fatty acid catabolism are also associated with cessation-related weight gain (Filozof et al. 2004). One change is fat oxidation, which regulates energy intake. If during the cessation process the lipid intake is not modulated, the imbalance in lipid intake and fat oxidation may lead to an increase in body fat. Another change in adipose tissue metabolism is increased lipoprotein lipase activity, which has been suggested to be associated with weight gain during the smoking cessation process. However, in the same study with a small sample size, smoking cessation was not associated with an increase in adipose cell size. The mechanisms by which cigarette smoking reduces body weight are presented in Figure 3.

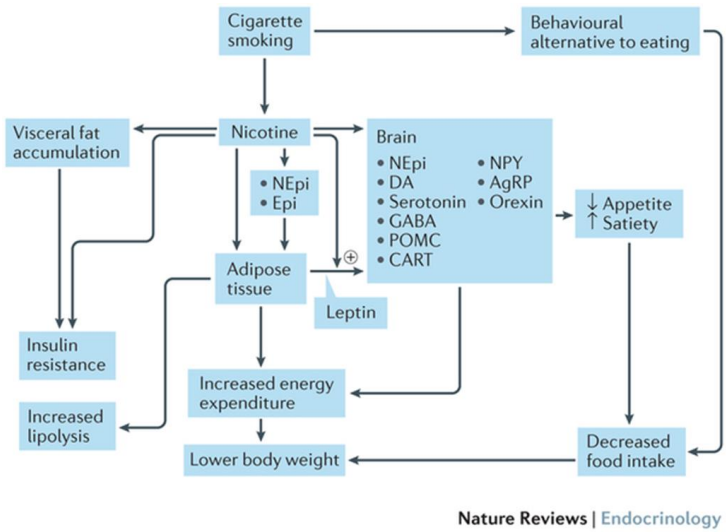

Figure 3. *Mechanisms by which cigarette smoking reduces body weight. Adapted from Harris et al 2016. Reprinted with permission.*
Abbreviations: AgRP, agouti-related protein; CART, cocaine- and amphetamine-regulated transcript protein; DA, dopamine; Epi, adrenaline; GABA, γ-aminobutyric acid; NEpi, noradrenaline; NPY, neuropeptide Y; POMC, proopiomelanocortin.

2.4 Need for the present study

Smoking-specific weight concerns have mostly been studied in the USA, however, the phenomenon has not been previously investigated in the Finnish population. Such a phenomenon might be partly cultural-related. Only a few reports exist regarding the level of weight concerns according to smoking status. Hence, Study I describes the level of weight concerns and gender differences according to smoking status in a Finnish population-based sample. Further, knowledge of associations between weight concerns and other cessation-related factors is limited. Study II focuses on essential determinants of smoking cessation, self-efficacy and motivation to quit, and their associations with weight concerns.

Despite the wealth of literature about smoking-specific weight concerns, there is still inconsistency regarding whether and how weight concerns predict smoking cessation. There are only a few studies with sufficiently long follow-ups and well-controlled confounding factors investigating this issue. In addition, most of the studies have been based on clinical samples. There is a demand to investigate mediators and moderators between weight concerns and later smoking cessation, but yet they are insufficiently established. Thus, in Study III, the role of weight concerns is examined in smoking cessation while taking into account the interplay with nicotine dependence, an essential determinant of cessation. Further, self-efficacy and motivation to quit are tested as possible mediators.

Although the associations of smoking with abdominal obesity are well established, there is a need for a deeper understanding of this phenomenon. For example, earlier studies have mainly not addressed any interplay between smoking and weight on abdominal obesity. Hence, Study IV analyses waist circumference levels according to combined smoking–BMI status. The lack of knowledge regarding smoking-specific weight concerns in the Finnish population is obvious, therefore, in this thesis, it is the main focus (Studies I – III). Further, associations of smoking with abdominal obesity are assessed as an indicator of weight concerns' health-related component (i.e., is there a health-justified matter for smokers to have concerns about weight and post-cessation weight gain).

3 Aims of the study

This study was undertaken to examine the interplay between smoking and weight concerns in cross-sectional and longitudinal settings, and between smoking and abdominal obesity in cross-sectional settings in Finnish adults at the population level.

The specific aims of the study were as follows:

1. To assess levels of weight concerns among ever-smokers (I).

2. To investigate the association of weight concerns with self-efficacy and motivation to quit smoking among daily smokers (II).

3. To investigate the role of weight concerns as a predictor of smoking cessation (III).

4. To assess the associations of smoking with abdominal obesity in ever- and never-smokers (IV).

4 Materials and methods

4.1 Study design and methods

4.1.1 Data

This thesis is based on the National FINRISK 2007 study and its subsample the DIetary, Lifestyle and Genetic Determinants of Obesity and Metabolic Syndrome (DILGOM 2007), a subsample of ever-smokers, and the DILGOM 2014 follow-up. The flowchart of the applied data is presented in Figure 4. FINRISK studies have been collected since 1972 with a 5-year frequency to monitor risk factors in major non-communicable diseases (Peltonen et al. 2008a, Peltonen et al. 2008b, Borodulin et al. 2017). For every FINRISK study, an independent random sample was drawn from the Population Register. For FINRISK 2007, a sample of 10,000 participants aged 25 to 74 years, with stratification by gender, 10-year age group, and 6 geographical regions, were invited to participate. Regions fully involved (i.e., questionnaire and health examination) were the following: 1) North Karelia, 2) Northern Savo, 3) Turku, Loimaa and 9 other municipalities in the region of southwestern Finland, 4) Helsinki and Vantaa from the capital area, and 5) provinces of Northern Ostrobothnia and Kainuu in northern Finland. In addition, the self-administered questionnaires were mailed to the province of Lapland. In all, the FINRISK 2007 study comprises 123 municipalities. In regions 1–5, participants were asked to fill in a self-administered questionnaire, participate in a health examination, and give a blood sample. In total, 6258 individuals participated in the health examinations conducted by research nurses from January to April in 2007. The 5817 participants with information on independent, dependent, and confounding variables formed the data for Study IV.

From FINRISK 2007, a subsample entitled DILGOM 2007 was formed to gather more detailed information about diabetes and its major risk factors in the Finnish population (Peltonen et al. 2008b, Konttinen et al. 2009). Of the 6258 invited participants, 5024 participated. This group filled in an additional questionnaire, participated in an additional health examination, and an additional venous blood sample was drawn. The DILGOM 2007 study includes a substudy regarding detailed smoking and nicotine dependence questions, a subsample of ever-smokers (Broms et al. 2012). Ever-smokers were identified from the FINRISK 2007 participants with two different questions depending on the region. The ever-smokers were identified by the question “have you smoked at least 100 cigarettes during your lifetime” in regions 2–4 and by the question “do you smoke currently” in regions 1 and 5 (Broms et al. 2012). Hereby, from regions 2–4, daily and occasional smokers, recent quitters, and former smokers were included, and from regions 1 and 5 only current daily and occasional smokers were included. From all of the 1922 ever-smokers, 1746 returned the questionnaire regarding smoking and formed the subsample of ever-smokers data. Ever-smokers with information on independent, dependent, and confounding variables (n=1614)

formed the data for Study I. In addition, plasma cotinine was analysed for all ever-smokers who gave permission during the FINRISK 2007 data collection (n=1158). From those ever-smokers granting permission, 600 total self-reported daily and occasional smokers with cotinine verification (≥ 10 µg/l; meaning currently smoking) and no missing information on independent, dependent, and confounding variables formed the data for Study II.

In 2014, 4581 participants from DILGOM 2007 were invited to participate in the DILGOM 2014 follow-up. From invited people, 3359 participated and formed the DILGOM 2014 data. The DILGOM 2014 consisted of a health questionnaire in regions 1–5. In addition, health examinations were done, a venous blood sample drawn, and expired air carbon monoxide (CO) taken in regions 3–4. The DILGOM 2014 questionnaire included more detailed smoking-related questions for ever-smokers. In the DILGOM 2014 questionnaire, most of the smoking-related questions were repeated in the same form they were in in the 2007 questionnaires. From those baseline daily smokers from the subsample of ever-smokers (n=618), 402 participated in DILGOM 2014, and 355 provided information for all the applied variables, thereby forming the main data for Study III. For DILGOM 2014, blood cotinine (n=504) and expired air CO (n=1289) measures were taken in regions 3 and 4. From those, 128 had no missing information in any applied variables, and formed the subdata to be used for verification of self-reported smoking status with CO in 2014 for Study III.

The FINRISK 2007, DILGOM 2007 and DILGOM 2014 studies were approved and conducted according to the guidelines by the Ethics Committee of the Hospital District of Helsinki and Uusimaa. All participants gave their written informed consent.

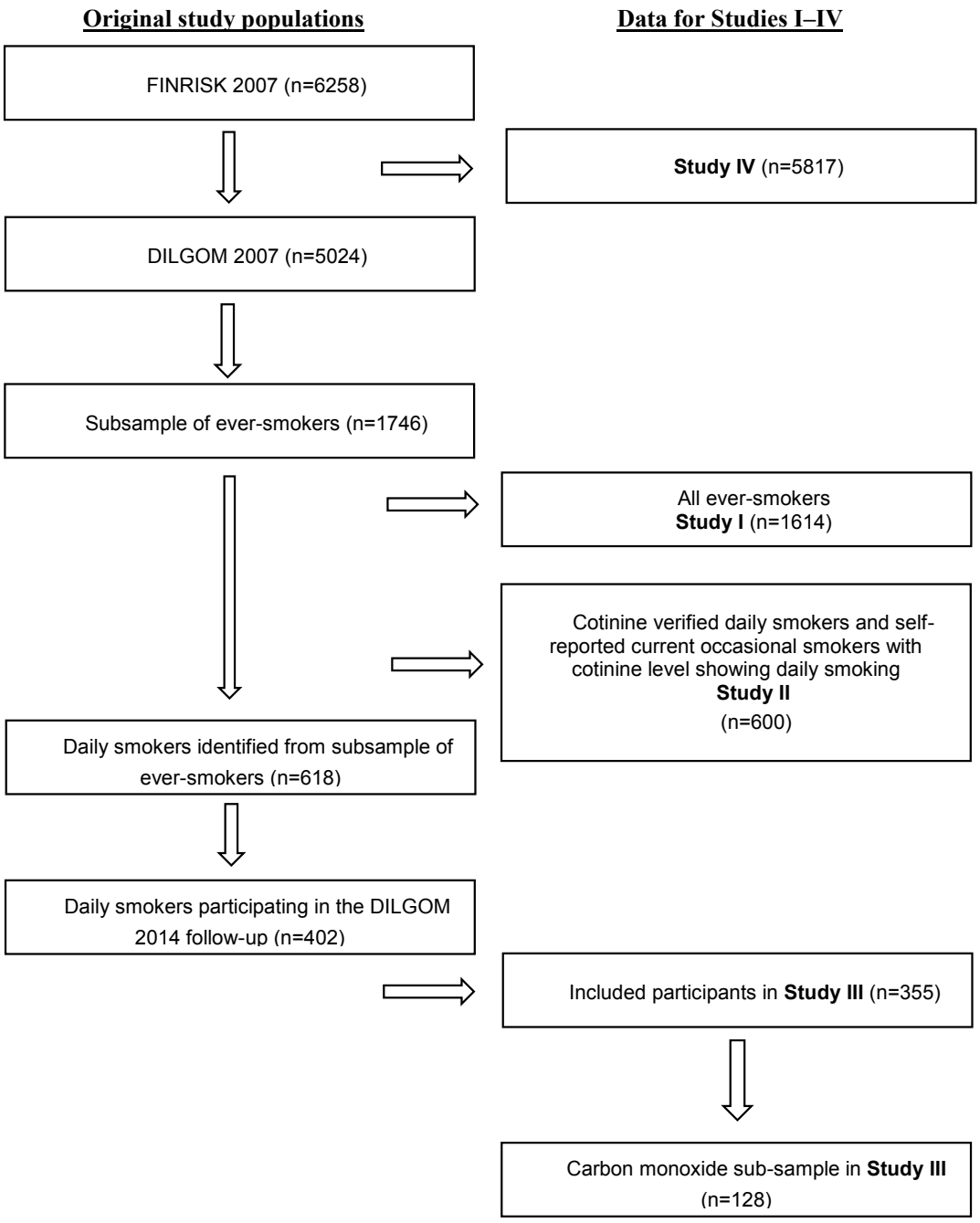

Figure 4. *Flowchart illustration of datasets, FINRISK 2007, DILGOM 2007, a subsample of 2007 ever-smokers, and DILGOM 2014 studies, and participants included in the studies of this thesis.*

4.1.1 Questionnaire measurements

Smoking status

In all Studies (I–IV), smoking status was assessed using variables which were developed at the National Institute for Health and Welfare. In this thesis, current smokers who smoke on a daily basis are referred as daily smokers and current non-daily smokers with previous cigarettes smoked more than 1–2 days ago but less than month ago are referred as occasional smokers. In addition, those with a non-smoking period less than 6 months, are referred to as recent quitters, and those who have quit 6 or more months ago, are referred to as former smokers. When recent quitters and former smokers are combined, the term used is ex-smokers. Different Studies use slightly different classifications of smoking status because different questionnaires had slightly different questions regarding smoking. In addition, those ever-smokers who had major inconsistencies in their answers regarding smoking were excluded from the study.

Studies I–II

From the subsample of ever-smokers, ever-smokers were categorised into daily smokers, occasional smokers, recent quitters, and former smokers according to the answers they filled in in the tobacco-related questionnaire in 2007. The following three questions were applied to form the mentioned four groups: 1) "Have you ever smoked regularly, almost every day for at least a year?", 2) "Do you smoke now?" and 3) "When was the last time you smoked?". Daily smokers were those who gave a positive answer to the first question, and an answer "yes, daily" to the second question, and "yesterday or today" for the last question; occasional smokers were those with a negative or positive answer to the first question, "yes, occasionally" to the second question, and "two days to a month ago" for the last question. Recent quitters were those with answers "yes", "no", and "two days to maximum 6 months ago" to the three questions, and former smokers were those with answers "yes", "no", and "6 months or more ago", respectively. Daily smokers, occasional smokers, recent quitters, and former smokers formed the sample for Study I. Daily and occasional smokers with cotinine verification (>10 μg/L) formed the sample for Study II.

Study IV

From the FINRISK 2007 questionnaire, self-reported smoking status was ascertained applying the following questions: 1) "Have you ever smoked?", 2) "Have you ever smoked at least 100 cigarettes during your lifetime?", 3) "Do you smoke currently?", 4) "Have you ever smoked regularly (for at least a one year period)?", and 5) "When was the last time you smoked?". Those who answered "no" to questions 1 and 2 were classified as never smokers. Those who answered "yes" for the first four mentioned questions and "yesterday or today"

for the fifth question were classified as daily smokers, those who answered "yes" for the first three questions, "no" for the fourth question, and "two days to a month ago" to the fifth question were classified as occasional smokers. In addition, those who answered "yes" for the two first questions and "no" for question three were classified as ex-smokers. Those who answered "no" for the first or second questions were classified as never-smokers. In addition, daily smokers were divided into light/moderate and heavy smokers according to their response to the question "How many manufactured cigarettes or hand-rolled cigarettes do you smoke on average in a day?" Those who smoked 19 or fewer CPD were classified as light/moderate smokers and those who smoked 20 or more CPD were classified as heavy smokers. The following classification was applied in Study IV: never smokers, ex-smokers, occasional smokers and light/moderate daily smokers, and heavy daily smokers.

Study III

All self-reported daily smokers from DILGOM 2007 formed the baseline sample for Study III. Self-reported daily smokers were formed similarly as explained earlier for Study I. From the DILGOM 2014 questionnaire, self-reported smoking status was measured applying the same questions that were applied for Study I. For Study III, a three-category variable "current daily smokers/occasional smokers/ex-smokers" was applied as an outcome.

Weight concerns

Weight concerns were measured by applying a modified version of the Weight Concern Scale initially developed by Borrelli & Mermelstein (Borrelli & Mermelstein 1998). The applied Weight Concern Scale was pre-tested in small number of participants answering to it before implanting it to the questionnaire. The original sixth question from the Borrelli & Mermelstein Weight Concern Scale "How likely is it that you would go back to smoking after quitting, if you gained too much weight?" was replaced with another question. The reason is that the questions in this study were administered to all ever smokers whereas the initial scale was targeted to smokers who are planning to quit. The added question was "How important is replacing meals with cigarettes/snus for your weight control?" to include a question that is more suitable for snus-users and current smokers not intending to quit. Furthermore, the change was done to measure more precisely the actual behaviour rather than an assumption what might happen when possible weight gain occurs. Also, to make weight concern questions more suitable for former smokers, the following statement was added to the heading of the weight concern questions: "What is or was the significance of the following weight-related issues in relation to your smoking? If you do not smoke cigarettes any longer, answer according to the time you last smoked". The questions included in the modified Weight Concern scale are shown in Table 8.

In this modified Weight Concern Scale, two questions measure post-cessation weight gain concerns, two questions measure smoking-related dieting behaviour, and two questions measure smoking-related weight beliefs. The response options were: 1 (not at all or very little), 2 (a little), 3 (moderately), 4 (fairly), and 5 (very much). A sum score was constructed,

with a range of 6 to 30. For statistical reasons, a transformation from the 1 to 5 scoring was made by subtracting one from each response, thereby ending up at sum score based on scoring from 0 to 4. The Weight Concern Scale was applied as a continuous sum score variable ranging from 0 to 24 in Studies I–III. In order to illustrate internal consistency among different Studies, and among groups of ever-smokers, Cronbach's αs were calculated separately for daily and occasional smokers, recent quitters, and former smokers. These results are only presented in the thesis summary.

In order to illustrate the prevalence of weight concerns among ever-smokers, a dichotomy of non-weight-concerned vs. weight-concerned was created. There is no consistency in the literature about the threshold between non-weight-concerned and weight-concerned. For this thesis, the threshold of ≥6 was selected due to the following reasons. First, I wanted to present a conservative estimate. The lowest answer option (i.e., 0) is "not at all or very little". So the scale cannot precisely distinguish those without any weight concerns from those having very little. However, a crude estimate provides the perspective regarding this phenomenon in Finnish adults at the population level. Moreover, question number five alone does not measure actual weight concerns but rather the assumption of the likelihood of possible weight gain during the smoking cessation process. This weight gain can have previously occurred and thus is a realistic assumption rather than a concern. If a person answers "very much" to question number five, but "not at all or very little" to all other questions, he/she scores four, and is appropriately classified as non-weight-concerned. Therefore, the minimum threshold could be five. To be more cautious and systematic while presenting this crude estimation, the threshold was set to ≥6 for weight-concerned. To score at least six, a person had to answer consistently at least "a little" for all the questions or alternatively answer at least "moderately" for some questions while answering "not at all or very little" to some questions. To illustrate the shortened version of the Weight Concern Scale for clinical use, a sum score variable including questions two, three, and four, and ranging from 0 to 12 was created. These results are reported only in the thesis summary.

Table 8. *Modified Weight Concern Scale administered to ever smokers within the DILGOM 2007 survey.*

What is or was the significance of the following weight-related issues in relation to your smoking? If you do not smoke cigarettes any longer, answer according to the time you last smoked.				
Questions				
1. How important is losing weight or maintaining your current weight compared to other personal health concerns? 2. People smoke for many reasons. Compared with all of your reasons for smoking, how important is smoking to control your weight? 3. How much does smoking cigarettes help you to control your weight? 4. How concerned are you about gaining weight as a result of quitting? 5. How likely do you think it is that you will gain weight as a result of quitting? 6. How important is replacing meals with cigarettes/snus for your weight control?				
Answer options (after subtraction)				
0 (not at all or very little)	1 (a little)	2 (moderately)	3 (fairly)	4 (very much)

Self-efficacy to quit smoking

Self-efficacy to quit smoking was measured with the question "If you were to try to quit smoking, how much confidence would you have that you could quit it for good?". Response options were on a numerical 0–10 scale reflecting the spectrum from "no confidence at all" to "very confident". Self-efficacy to quit was applied as a continuous variable in Studies II and III.

Motivation to quit smoking

Motivation to quit smoking was measured with the question "How willing are you to quit smoking for good?" Response options were on a numerical 0–10 scale reflecting the spectrum from "no willingness at all" to "very great willingness". In the subsample of ever-smokers, motivation to quit was asked first and self-efficacy to quit immediately afterwards. Motivation to quit was applied as a continuous variable in Studies II and III.

Nicotine dependence

Nicotine dependence was measured by the Fagerström Test for Nicotine Dependence (FTND) (Fagerström 1978, Heatherton et al. 1991). The FTND was applied as a continuous adjustment variable in Studies II–III and as a dichotomous classifying variable with a cut-off of ≥4 in Study III (Fagerström & Furberg 2008, Fagerström et al. 2012). The FTND comprises six questions (see Table 4 in Section 2.1.4 Nicotine dependence), and the score ranges 0–10 (Heatherton et al. 1991).

Physical activity

Physical activity was self-reported in the questionnaire. For Studies I and II, the level of physical activity was measured as the frequency of weekly leisure time physical activity which caused sweating and lasted at least 20 minutes. The score for physical activity ranged from one to seven. Physical activity was used as a continuous variable in the regression models, and a dichotomy of physically active/inactive with a cut-off of ≥3 for the descriptive results in Study I. In Study II, the mean value of physical activity was illustrated. In Studies III–IV, adjusting for physical activity was done by the total physical activity index developed by Borodulin (Borodulin et al. 2016). The total physical activity index is a combination of leisure time physical activity, commuting physical activity, and occupational physical activity. The question assessing leisure time physical activity is: "How much do you exercise and stress yourself physically in your leisure time? If it varies much according to the different seasons, mark the alternative which best describes the average situation.", with response options as follows: 1) In my leisure time, I read, watch TV, and work in the household with tasks that do not make me move much and that do not physically tax me; 2) In my spare time, I walk, cycle, or exercise at least 4 h/week. This includes walking, fishing and hunting, light gardening, etc., but excludes travel to work; 3) In my spare time, I exercise to maintain my physical condition, e.g., running, jogging, skiing, gymnastics, swimming, playing ball games, or I do heavy gardening or the like for at least 3 h/week; and 4) In my spare time, I regularly exercise several times a week by participating in competitive sports such as running, orienteering, skiing, swimming, ball games, or other heavy sports. The following question assessed commuting physical activity: "How many minutes do you walk, ride on a bicycle or otherwise exercise to get to work? (Please count both traveling to and from work.)", with the following response options: 1) I do not work or I use only a motorised vehicle; 2) less than 15 min daily; 3) 15–29 min daily; 4) 30–44 minutes daily; 5) 45–59 min daily; and 6) over an hour daily. The question assessing occupational physical activity was the following: "How demanding is your work physically?", with the following response options: 1) My work is mainly done sitting down and I do not walk much during my working hours (e.g., a clock smith, radio mechanic and industrial seamstress, office work at a desk); 2) I walk quite a bit in my work, but I do not have to lift or carry heavy objects (e.g., a foreman and store assistant, light industrial worker, office work that requires walking); 3) I have to walk and lift a lot or to take the stairs or go uphill (e.g., a carpenter or cattle minder/dairy work, engineering shop or other heavier industrial work); and 4) My work is heavy manual labour in which I have to lift or carry heavy objects, to dig, to shovel, or to chop (e.g., forestry, heavy farm work, heavy construction or industrial work). The total physical activity index includes four categories: inactive, low, medium, and high. However, total physical activity was applied as a continuous variable, with the higher number standing for higher physical activity level, to ensure its statistical power.

Education

In Study I, education was used as a continuous confounding variable. Self-reported education was graded as primary (comprehensive school), secondary (vocational school, upper secondary school, and polytechnics), and tertiary (academic) levels of education and transformed into years of education. In Study III, education was used as a three-category variable as recommended in the International Standard Classification of Education (UNESCO 2012). Education was self-reported years studying full time, and divided as birth cohort-stratified tertiles: low, intermediate, and high.

Alcohol consumption

In Studies I and IV, alcohol consumption was applied as a confounding variable. Alcohol consumption was self-reported use of alcohol products in the previous 12 months, calculated as the average daily alcohol consumption in grams. Alcohol consumption was applied as a trichotomy: abstainers, light to moderate users, and heavy users in Study I. In Study IV, alcohol consumption was assessed as the self-reported use of alcohol products in the previous week, calculated as average weekly alcohol consumption in 100% ethanol grams and applied as a continuous logarithmically-transformed variable.

Marital status

Marital status was a confounding variable in Study I, and applied as a dichotomous living with partner/living alone.

Fat and fibre intake

For Study I, the daily fat and fibre intake was applied as a continuous confounding variable (Kaartinen et al. 2012). Fat and fibre intake was a self-reported average consumption of foods containing fat and fibre, and further calculated to an average portion (g/day). Fat and fibre intake were indicators of dietary behaviour.

Age

All Studies (I–IV) were adjusted for age in years. The exact age was calculated using the birth date and response date.

Gender

Gender was a self-reported dichotomy verified by the gender status from the personal identity number.

4.1.2 Anthropometric measurements

Weight, height, and body mass index (BMI)

Weight and height were measured by the research nurse according to international protocols (Tolonen et al. 2008). BMI was calculated by dividing the weight in kilograms by the square of height in meters (kg/m^2). BMI was used as a continuous variable as a covariate in Studies I and II and IV; additionally, in Study IV, participants were divided into two groups according to their BMI with the cut-off point of 25 (kg/m^2).

Waist circumference

Waist circumference was measured by the research nurse at the midpoint between the top of the iliac crest and the lower margin of the last palpable rib in the mid-axillary line as recommended by the WHO (WHO 2011). In Study IV, waist circumference was used as a continuous variable in centimetres.

4.1.3 Biochemical measurements

Cotinine

A research nurse took a fasting venous blood sample for cotinine determinations from those participants in the subsample of ever-smokers who gave permission at the baseline 2007. Cotinine was analysed with a gas chromatograph–mass spectrometer (Broms et al. 2012). In Study II, cotinine was applied as a dichotomous "not current daily smoker (≤10 μg/L)" versus "current daily smoker (>10 μg/L)". In Study III, cotinine was applied as a continuous variable to show correlations.

Carbon monoxide (CO)

A research nurse took expired air CO measures in the DILGOM follow-up in 2014 from the subsample of ever-smokers. CO was applied dichotomously to test the reliability of self-reported smoking status among daily and ex-smokers in 2014.

4.1.4 Summary table of the applied variables

Table 9. *Summary of the applied variables.*

Variable	Predictor	Outcome	Covariate/Other
Smoking status	I, IV	III	
Weigth Concerns	I–III		
Self-efficacy to quit		II	IV
Motivation to quit		II	
FTND	III		II–III
Physical activity			I–IV
Education			I, III
Alcohol consumtion			I, IV
Marital status			I
Fat and fibre intake			I
Age			I–IV
Gender			I–IV
Body mass index	IV		I,II & IV
Waist circumference		IV	
Cotinine			II, III
Carbon monoxide			III

FTND, Fagerström Test for Nicotine Dependence

4.2 Statistical methods

A sum score ranging 0 to 24 from the Weight Concern Scale questions was created. For comparison of descriptive characteristics, one-way analyses of variance (ANOVA) and Pearson's chi-square were conducted (I–IV). Statistical analyses to obtain the β estimates and 95% confidence intervals (CIs) were performed using multiple linear regression models (I, II, IV). To obtain relative risk ratio (RRR) and 95% CIs, multinomial logistic regression models were performed (III). Significance was set at $p<0.05$, except for interaction testing, for which statistical significance was set at $p<0.10$. Non-overlapping confidence intervals were considered to be significant (I, IV).

Interaction between gender and smoking status on weight concerns (I), and between smoking status and BMI on waist circumference separately for men and women (IV), were tested by comparing models with and without an interaction term with the likelihood-ratio test. Interaction between weight concerns and FTND on subsequent smoking status, and between weight concerns and gender on subsequent smoking status, were tested by the Wald test (III). The weight concerns by gender interaction is only reported in the thesis summary.

Because of overlapping confidence intervals, post hoc tests were performed with the pair-wise difference test for the association of smoking status with waist circumference (IV).

Logarithmic transformation was done for the non-normally distributed variable, alcohol consumption (IV). In addition, alcohol consumption was applied as a three-category variable: abstainers, moderate users and excessive users (I).

To examine linearity, the distributions of weight concerns, motivation to quit, and self-efficacy to quit were tested by Tukey's ladder of powers test to find a transformation that revealed the most linear relationship (Tukey 1977), but we decided not to transform any. These were not reported in sub-studies. To illustrate the internal consistency of the Weight Concern Scale in our different datasets (I–III), among different groups of ever-smokers, and in the shortened version, Cronbach's αs were calculated (Nunnally & Bernstein 1994).

Self-efficacy and motivation to quit were tested regarding whether they were mediators between weight concerns and later smoking status separately. The following pattern was applied: first it was tested if there was a significant variation in the relationship between the predictor and the outcome, then it was tested if there was a significant variation in the relationship between the predictor and the proposed mediator. Finally, it was tested if there was a significant change in the relationship between the predictor and the outcome when the model took into account the mediator (Baron & Kenny 1986). This mediator testing is only reported in the thesis summary.

The Pearson's correlation coefficients were calculated to assess correlations between weight concerns, self-efficacy to quit, motivation to quit, age, BMI, physical activity and FTND (II); to assess correlations between weight concerns, FTND, and cotinine (III); and to assess correlations between BMI, waist circumference, age, physical activity index and alcohol consumption (IV). The reliability of self-reported smoking status (current daily smoker vs. ex-smoker) was determined by calculating Cohen's Kappa in relation to CO levels (Landis & Koch 1977) (III).

Crude prevalences of weight concerns were estimated applying the dichotomy non-weight-concerned/weight-concerned with a threshold of ≥6 for weight-concerned. A sum score ranging from 0 to 12 from Weight Concern Scale questions two, three, and four was created. These results were not reported in sub-studies. All statistical analyses were carried out using Stata® statistical software versions 11.0 and 13.1 (StataCorp 2009, StataCorp 2013).

5 Results

5.1 Weight concerns among ever-smokers (Study I)

The Weight Concern Scale exceeded the recommended internal consistency, Cronbach's α >0.7, in our different datasets (Nunnally & Bernstein 1994). Cronbach's αs were 0.90 for Studies I–III. In addition, the Weight Concern Scale had high internal consistency among different groups of ever-smokers. Cronbach's αs were 0.90 for daily smokers, 0.80 for occasional smokers, 0.80 for recent quitters, and 0.86 for former smokers. Weight concerns were found to be associated with smoking status. Occasional smokers, recent quitters and former smokers had lower weight concern sum scores compared to daily smokers in age-adjusted models for men (β -3.53, 95% CI -4.62 to -2.44 for occasional smokers; β -3.35, 95% CI -5.02 to -1.68 for recent quitters; β -1.11, 95% CI -1.90 to -0.31 for former smokers) and for women (β -4.61, 95% CI -5.99 to -3.23 for occasional smokers; β -5.27, 95% CI -7.25 to -3.31 for recent quitters; β -2.41, 95% CI -3.43 to -1.39 for former smokers).

Adjusting for potential confounders did not markedly change the results: for occasional smokers (β -3.25, 95% CI -4.34 to -2.21), for recent quitters (β -3.87, 95% CI -5.54 to -2.21), or for former smokers (β -1.51, 95% CI -2.22 to -0.72) among men, nor among women, respectively (β -4.21, 95% CI -5.57 to -2.87; β -5.53, 95% CI -7.46 to -3.59; β -2.55, 95% CI -3.56 to -1.53). The final model accounted for 18% (R^2) of the weight concerns' variance among men and 20% (R^2) among women. Women had higher weight concern sum scores (mean 8.25) than men (mean 6.93), $p<0.001$.

In total, 51% of men and 55% of women were weight-concerned. Among daily smokers and former smokers, the majority were weight-concerned, while among occasional smokers and recent quitters the minority were weight-concerned. This trend was similar among both genders. These results are shown in Figures 6 and 7, and are reported only in the thesis summary.

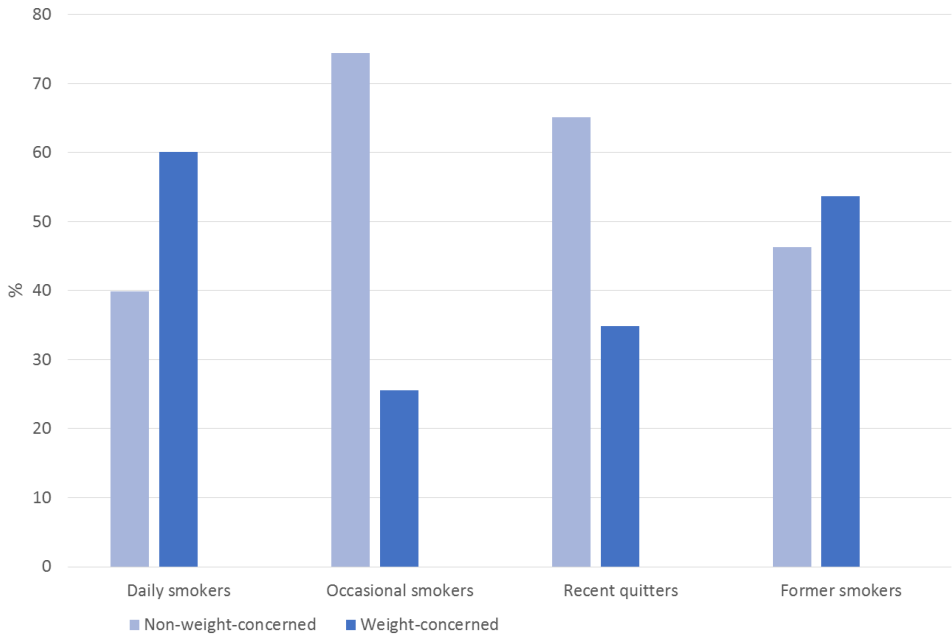

Figure 6. *The prevalence of weight concerns for men by smoking status, n=899.*

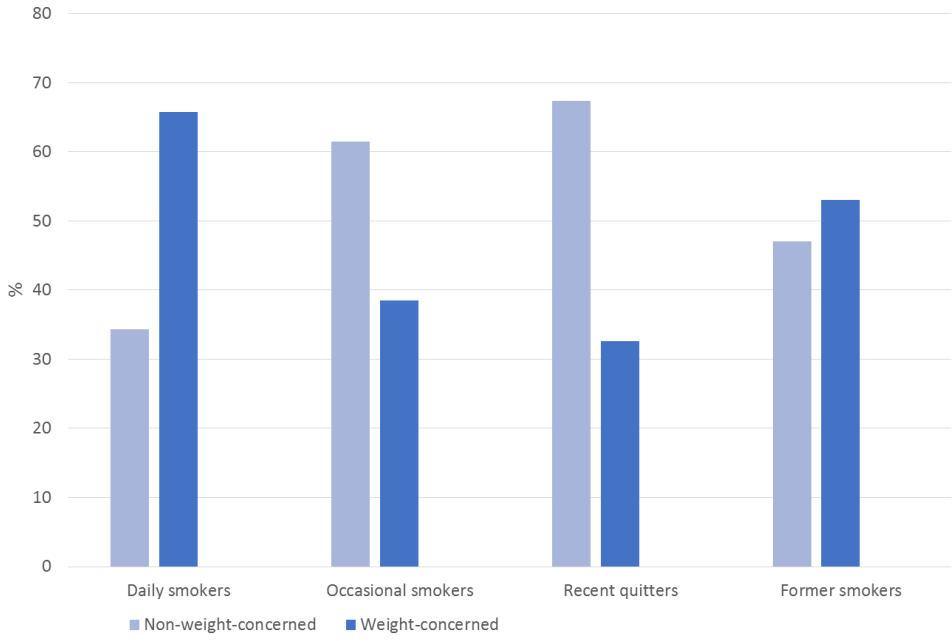

Figure 7. *The prevalence of weight concerns for women by smoking status, n=715.*

5.2 Weight concerns, self-efficacy and motivation to quit (Study II)

Weight concerns were inversely associated with self-efficacy in models adjusted for gender, age, BMI, and physical activity (β -0.07, 95% CI -0.11 to -0.02). Nicotine dependence attenuated the association between weight concerns and self-efficacy (β -0.04, 95% CI -0.08 to -0.01). The final model accounted for 15% (R^2) of the self-efficacy's variance. Weight concerns were not associated with motivation to quit (β 0.03, 95% CI -0.00 to 0.07 in the final model). The final model accounted for only 1% (R^2) of the motivation's variance (Study II).

Table 10. *Results of the multiple linear regression models for weight concerns and self-efficacy to quit: among (A) self-reported daily and occasional smokers with cotinine verification, n=600, and (B) self-reported daily smokers, n=583.*

	1st Model	2nd Model	3rd Model	Final Model
			A	
β	-0.07	-0.07	-0.07	-0.04
95% CI	-0.11, -0.04	-0.10, -0.03	-0.11, -0.02	-0.08, -0.01
Adj. R^2	0.03	0.03	0.06	0.15
			B	
β	-0.06	-0.05	-0.06	-0.04
95% CI	-0.09, -0.02	-0.09, -0.01	-0.09, -0.02	-0.07, -0.00
Adj. R^2	0.02	0.02	0.05	0.11

Modified from Tuovinen et al. 2015 (Study II)
Model 1 adjusted for gender and age
Model 2 further adjusted for BMI
Model 3 further adjusted for physical activity
Final model further adjusted for nicotine dependence
β, β coefficients; CI, confidence interval

Table 11. *Results of the multiple regression models for weight concern sum scores and motivation to quit: among A) self-reported daily and occasional smokers with cotinine verification, n=600, and B) self-reported daily smokers, n=583.*

	1st Model	2nd Model	3rd Model	Final Model
			A	
β	0.02	0.03	0.03	0.03
95% CI	-0.01, 0.05	-0.01, 0.06	-0.01, 0.06	-0.00, 0.07
Adj. R^2	0.01	0.01	0.02	0.01
			B	
β	0.02	0.03	0.02	0.03
95% CI	-0.01, 0.06	-0.01, 0.06	-0.01, 0.06	-0.01, 0.06
Adj. R^2	0.01	0.01	0.03	0.03

Modified from Tuovinen et al. 2015 (Study II)
Model 1 adjusted for gender and age
Model 2 further adjusted for BMI
Model 3 further adjusted for physical activity
Final model further adjusted for nicotine dependence.
β, β coefficients; CI, confidence interval

The extension of the data with cotinine-verified occasional smokers was relevant because it increased the amount of variance of self-efficacy explained by weight concerns with the confounders. The association between weight concerns and self-efficacy to quit among daily smokers with cotinine-verified expansion with occasional smokers and among daily smokers only are shown in Table 10. For self-reported daily and occasional smokers with cotinine verification (A), the final model accounted for 15% of the variance, while for self-reported daily smokers (B), the final model accounted for only 11%. The β estimates were exactly the same in both groups in the fully-adjusted model (β -0.04). Weight concerns were not associated with motivation to quit in self-reported daily smokers (B) (β 0.03, 95% CI -0.01 to 0.06 in the final model). The association between weight concerns and motivation to quit among daily smokers with cotinine-verified expansion with occasional smokers and among daily smokers only are shown in Table 11. These results were not reported in Study II.

5.3 Weight concerns and smoking cessation (Study III)

Weight concerns predicted the transition to occasional smoker in the age and gender-adjusted model only. When further adjusted for FTND, none of the results were statistically significant any longer. These results are only presented in the thesis summary in Table 12. Also, FTND was tested as a predictor for subsequent smoking status. These results are only presented in the thesis summary. Continuous FTND predicted smoking cessation (RRR 0.90, 95% CI 0.86 to 0.99) and transition to occasional smoking (RRR 0.67, 95% CI 0.55 to 0.81) in the age and gender-adjusted model. Dichotomous FTND with a threshold ≥4 for high nicotine dependence predicted transition to occasional smoking (RRR 0.12, 95% CI 0.04 to 0.35) but not smoking cessation (RRR 0.72, 95% CI 0.44 to 1.2) in the age and gender-adjusted model.

The interaction between weight concerns and FTND on subsequent smoking status was significant (Likelihood ratio Chi-Square (LR χ^2) 6.37, p=0.04), whereas the interaction between weight concerns and gender on later smoking status was not significant (LR χ^2 1.59, p=0.45). The latter result was not reported in Study III. Because there was interaction between weight concerns and FTND, further analyses were done according to nicotine dependence level with a threshold of FTND ≥4 for the high nicotine dependent group. Weight concerns at baseline (2007) predicted subsequent smoking status at 2014 only for daily smokers with low nicotine dependence. Higher weight concerns predicted less probable smoking cessation (RRR 0.92, 95% CI 0.86 to 0.99) and less probable reduction of smoking from daily to occasional (RRR 0.88, 95% CI 0.80 to 0.98). Adjusting for potential confounders and FTND as a continuous variable did not change the result. Moreover, motivation to quit and self-efficacy were tested as mediators between weight concerns and subsequent smoking status, and are reported only in the thesis summary. They were not significant mediators in the association between weight concerns and subsequent smoking status. Among subjects with high nicotine dependence, weight concerns did not predict subsequent smoking status. The multinomial logistic regression results of weight

concerns as a predictor of later smoking status according to nicotine dependence level are presented in Table 13. Dichotomous weight concerns was also tested as a predictor for subsequent smoking status. These results are only presented in the thesis summary. Dichotomous weight concerns with a threshold ≥6 for highly weight-concerned predicted transition to occasional smoking (RRR 0.40, 95% CI 0.19 to 0.87) but not smoking cessation (RRR 0.63, 95% CI 0.38 to 1.02) in the age and gender-adjusted model. Further adjusting for FTND attenuated weight concerns as a predictor of transition to occasional smoking (RRR 0.44, 95% CI 0.20 to 0.98). A shortened version of the Weight Concern Scale was created, tested as a predictor for subsequent smoking status, and tested for internal consistency among daily smokers. The Cronbach's α was similar to the applied full-length version, 0.90. The shortened version predicted subsequent smoking status only among low nicotine dependent participants, similar to the full-length version in the age and gender-adjusted model (RRR 0.87, 95% CI 0.78 to 0.97 for smoking cessation and RRR 0.80, 95% CI 0.69 to 0.94 for transition to occasional smoking). At follow-up, self-reported smoking status was highly reliable. No self-reported ex-smoker had CO levels ≥8 ppm and Cohen's kappa agreement was 0.75 ($p<0.001$).

Table 12. *Results of multinomial logistic regression of weight concerns as a predictor of later smoking status, n=355.*

	1st Model		2nd Model	
	Occasional smokers	Ex-smokers	Occasional smokers	Ex-smokers
RRR	0.92	0.97	0.94	0.98
95% CI	0.86, 0.99	0.94, 1.01	0.87, 1.01	0.94, 1.02
Pseudo R^2	0.01		0.05	

Model 1 adjusted for gender and age
Model 2 further adjusted for nicotine dependence
RRR, Relative risk ratio; CI, confidence interval

Table 13. *Results of fully-adjusted multinomial logistic regression of weight concerns as a predictor of later smoking status according to nicotine dependence level.*

Low FTND (n=179)	RRR 95% CI	RRR 95% CI
Daily smokers (ref.)	Occasional smokers	Ex-smokers
1.00	**0.89**	**0.93**
	0.80, 0.98	**0.87, 0.99**
Gender	1.88	1.14
	0.73, 4.85	0.53, 2.43
Age	1.04	1.03
	1.00, 1.08	1.00, 1.07
Self-efficacy to quit	1.07	1.03
	0.86, 1.33	0.87, 1.22

Motivation to quit	0.94		**1.22**
	0.76, 1.16		**1.02, 1.43**
Physical activity index	**2.72**		0.92
	1.30, 5.72		0.60, 1.43
Education, intermediate	0.82		0.86
	0.25, 2.66		0.33, 2.21
Education, high	1.49		2.18
	0.47, 4.70		0.89, 5.32
Nicotine dependence	0.83		**0.70**
	0.54, 1.27		**0.50, 0.98**
Pseudo R^2		0.11	
High FTND (n=176)	RRR		RRR
	95% CI		95% CI
Daily smokers (ref.)	Occasional smokers		Ex-smokers
1.00	1.07		1.01
	0.90, 1.28		0.95, 1.07
Gender	0.29		0.64
	0.02, 3.76		0.30, 1.38
Age	0.87		0.98
	0.76, 1.01		0.95, 1.02
Self-efficacy to quit	**0.27**		1.05
	0.08, 0.87		0.90, 1.23
Motivation to quit	1.79		1.16
	0.90, 3.58		0.99, 1.35
Physical activity index	0.82		0.69
	0.14, 4.79		0.45, 1.06
Education, intermediate	7.84		1.36
	0.36, 169		0.58, 3.13
Education, high	1.16		1.79
	0.03, 42.7		0.67, 4.84
Nicotine dependence	0.97		0.98
	0.39, 2.38		0.76, 1.27
Pseudo R^2		0.11	

Modified from Tuovinen et al. Study III

Daily smokers in 2014 as reference group (RRR=1), n=355

Education: low as the reference group

CI, confidence intervals; FTND, Fagerström test for nicotine dependence; RRR, relative risk ratio

5.4 The association of smoking status with abdominal obesity (Study IV)

The unadjusted association between BMI and waist circumference was β 2.60, 95% CI 2.56 to 2.65 for men and β 2.33, 95% CI 2.29 to 2.36 for women. The unadjusted associations between smoking and weight, and between smoking and waist circumference, are presented in Table 14 and Table 15, respectively. Among men, only ex-smokers had a higher mean weight compared to never smokers (β 4.36, 95% CI 3.12 to 5.60). In addition, ex-smokers and heavy daily smokers had a larger mean waist circumference compared to never smokers (β 5.21, 95% CI 4.17 to 6.25 for ex-smokers and β 2.27, 95% CI 0.69 to 3.86 for heavy daily smokers). Among women, the mean weight did not differ between the smoking statuses. Ex-smokers and heavy daily smokers had a larger mean waist circumference compared to never smokers (β 1.22, 95% CI 0.04 to 2.39 for ex-smokers and β 2.97, 95% CI 0.10 to 5.84 for heavy daily smokers). These results are only presented in the thesis summary.

Table 14. *The association of smoking with weight and waist circumference among men, n=2738.*

	Never smokers	Ex-smokers	Occasional smokers and light/moderate daily smokers	Heavy daily smokers
			Weight	
β	reference	4.36	1.33	0.81
95% CI		3.12, 5.60	-0.19, 2.86	-1.07, 2.70
Adj. R^2			0.02	
			Waist circumference	
β	reference	5.21	0.91	2.27
95% CI		4.17, 6.25	-0.37, 2.19	0.69, 3.86
Adj. R^2			0.04	

β, β coefficients; CI, confidence interval

Table 15. *The association of smoking with weight and waist circumference among women, n=3079.*

	Never smokers	Ex-smokers	Occasional smokers and light/moderate daily smokers	Heavy daily smokers
			Weight	
β	reference	0.94	-0.74	2.22
95% CI		-0.29, 2.17	-2.15, 0.67	-0.79, 5.23
Adj. R^2			<0.01	
			Waist circumference	
β	reference	1.22	-1.16	2.97
95% CI		0.04, 2.39	-2.51, 0.18	0.10, 5.84
Adj. R^2			<0.01	

β, β coefficients; CI, confidence interval

There was a smoking status by BMI interaction on waist circumference among women (LR χ^2=6.85, p=0.009). Among the overweight/obese women, ex-smokers and heavy daily smokers had higher mean waist circumferences than never-smokers. No differences were found among men, normal weight women, or among a combined group of occasional, light and moderate daily smokers. All confounding factors were associated with waist circumference. The final model accounted for 85.5% of waist circumference's variance among women. These results are presented in Tables 16 and 17.

Table 16. *Results of the linear regression model for the associations of BMI–smoking status with waist circumference in men, n=2738.*

	Never smokers	Ex-smokers	Occasional and light/moderate daily smokers	Heavy daily smokers
		BMI<25		
β	Reference group	0.47	0.37	0.55
95% CI		-0.31, 1.25	-0.47, 1.21	-0.51, 1.60
		BMI≥25		
β	1.30	1.51	1.76	1.72
95% CI	0.63, 1.96	0.82, 2.19	1.00, 2.53	0.83, 2.61
		Adjustments		
	Age	BMI	Alcohol consumption	Physical activity index
β	0.12	2.39	0.27	-1.14
95% CI	0.11, 0.14	2.34, 2.45	0.08, 0.46	-1.35, 0.93

Modified from Tuovinen et al. 2016
Adjusted for age, BMI, alcohol consumption and physical activity index
Adjusted R-squared 85.9%
β, β coefficients; BMI, body mass index; CI, confidence interval

Table 17. *Results of the linear regression model for the associations of BMI–smoking status with waist circumference in women, n=3079.*

	Never smokers	Ex-smokers	Occasional and light/moderate daily smokers	Heavy daily smokers
			BMI<25	
β	Reference group	0.55	0.74	0.93
95% CI		-0.14, 1.25	-0.01, 1.50	-0.72, 2.59
			BMI≥25	
β	2.00	2.70	2.67	4.48
95% CI	1.36, 3.43	1.97, 3.43	1.85, 3.50	2.93, 6.03
			Adjustments	
	Age	BMI	Alcohol consumption	Physical activity index
β	0.05	2.14	0.20	-0.62
95% CI	0.03, 0.06	2.09, 2.19	-0.02, 0.42	-0.86, -0.39

Modified from Tuovinen et al. 2016 (Study IV)
Final model adjusted for age, BMI, alcohol consumption and physical activity index
Adjusted R-squared 85.5%
β, β coefficients; BMI, body mass index; CI, confidence interval

6 Discussion

This thesis was based on the population-based data from the large Finnish national FINRISK 2007 study, its DILGOM 2007 subsample, a subsample of ever-smokers, and the follow-up DILGOM 2014 sample. The thesis had two general aims: to examine the association of weight concerns with various smoking-related factors (I–III) and to examine the association between smoking and abdominal obesity (IV).

6.1 Summary of the main findings and comparison with previous studies

The first aim was to assess the level and gender differences of smoking-specific weight concerns among different subgroups of ever-smokers (Study I). These weight concerns were associated with smoking status: daily smokers had higher level of smoking-specific weight concerns than occasional smokers, recent quitters or former smokers in both genders. This finding is congruent with previous literature (French & Jeffery 1995). The finding that occasional smokers had less smoking-specific weight concerns than daily smokers is reasonable. Since occasional smokers tend to be more physically active and have better eating habits in comparison to daily smokers (Korhonen et al. 2009), they have healthier ways to control their weight. This healthier behaviour may, however, be motivated by general weight concerns. However, in the applied data, the DILGOM 2007 subsample of ever-smokers, general weight concerns were not assessed. Also, recent quitters had less smoking-specific weight concerns than daily smokers. This could be partly explained by the fact that they have not experienced the common cessation-related weight gain, which mainly appears during the first six months after smoking cessation (Klesges et al. 1997, Aubin et al. 2012), and thus are not worried about weight gain. In the previous literature, it has been suggested that smoking-related weight concerns and weight gain are independently associated with smoking cessation (French et al. 1992, Levine et al. 2010). Also, some subjects might find health-related concerns so important that they are ready to compromise body weight while quitting smoking, hence, the importance of smoking-related weight concerns could be less essential. This may be the case for former smokers, too. Overall, women had higher smoking-specific weight concern sum score means than men. This is in line with earlier studies (Jeffery et al. 2000, Pomerleau & Snedecor 2008). Although women do not gain weight more during cessation (Tian et al. 2015), they are, in general, less satisfied regarding their body size and shape than men (Pingitore, Spring & Garfield 1997).

The second aim was to investigate the association of weight concerns with self-efficacy and motivation to quit smoking among daily smokers (Study II). Weight concerns were found to have a weak negative association with self-efficacy to quit. Earlier findings support this result (Borrelli & Mermelstein 1998, Bowen et al. 2000, Jeffery et al. 2000, Sepinwall & Borrelli 2004). Nicotine dependence further attenuated the association between weight concerns and self-efficacy. This is reasonable, because nicotine dependence is associated

with both weight concerns (Jeffery et al. 2000, Pomerleau et al. 2001, Aubin et al. 2009, Germeroth & Levine 2018) and self-efficacy to quit (Li et al. 2015). Weight concerns were not associated with motivation to quit. Previous literature on this has been inconsistent. Negative associations (Clark et al. 2004, McKee et al. 2005) and positive associations (Sepinwall & Borrelli 2004) have been reported.

The third aim was to investigate smoking-specific weight concerns as a predictor of subsequent smoking status of daily smokers according to the nicotine dependence level (Study III). There was an interaction between weight concerns and nicotine dependence on subsequent smoking status. Higher levels of weight concerns were associated with a smaller likelihood to quit and transition into occasional smoking among baseline daily smokers with low nicotine dependence. Among daily smokers with high nicotine dependence, weight concerns were not significantly associated with subsequent smoking status. This is a novel finding, no previous literature has demonstrated weight concerns to predict subsequent smoking status according to nicotine dependence level. In addition, self-efficacy and motivation to quit were tested regarding whether they are mediating factors between weight concerns and subsequent smoking status. They were not significant mediators in this association, and these results are presented only in the thesis summary.

The fourth aim was to assess the associations of smoking, BMI, and waist circumference in ever- and never-smokers (Study IV). There was an interaction between smoking status and BMI on waist circumference, yet among women only. No prior studies have shown such an interaction. Among these women, overweight/obese heavy daily smokers and ex-smokers had larger mean waist circumferences compared to overweight/obese never smokers. Among men in all BMI categories, and among normal weight women, the mean waist circumferences did not differ by smoking status. Strong evidence exists that current daily smokers, especially heavy daily smokers, have more abdominal obesity compared to never smokers, both in women and men (Berlin 2008, Pisinger et al. 2009, Shi et al. 2013, Slagter et al. 2013, Lv et al. 2015, Morris et al. 2015). Furthermore, strong evidence also exists regarding abdominal obesity in ex-smokers compared to never-smokers in both genders (Pisinger, Jorgensen 2007a, Kwok et al. 2012, Sikorski et al. 2014, Lv et al. 2015, Tian et al. 2015). One reason why we failed to show the association among men and normal weight women might be that participants were not only categorised according to BMI, but that BMI was also further controlled for in the models. This was accurate to do, but may have reduced the power to detect differences between the association of smoking and waist circumference.

6.2 Smoking and weight concerns

A prevalence of a certain phenomenon, in this case smoking-specific weight concerns, provides public health relevance at the population level. Therefore, a prevalence for the weight-concerned subjects among each smoking group was created. Independent of smoking status, 51% of men and 55% of women were weight-concerned. Whereas among daily smokers, 60% of men and 66% of women were weight-concerned. In previous studies,

the prevalence has varied among men from 9 to 62% and among women from 30% to 86%, depending on the study population and the measure of weight concerns applied (Meyers et al. 1997, Jeffery et al. 2000, Pomerleau et al. 2001, Clark et al. 2006, Pomerleau & Snedecor 2008, Landrau-Cribbs et al. 2015, Pankova et al. 2016). The estimates presented in this thesis are conservative, therefore, it is safe to claim that the majority of daily smokers have at least some amount of smoking-specific weight concerns in the Finnish population. Because smoking is a major public health problem and the majority of Finnish daily smokers are weight-concerned, weight concerns should be considered as a public health problem, and actions allocated towards them.

Smoking-specific weight concerns have not been studied previously in Finland. However, a previous study about the associations of smoking with recurrent dieting exists (Saarni et al. 2007). In this study, recurrent dieting, one dimension of smoking-related weight concerns as defined by French and Jeffery (1995), was associated with ex-smoking in both genders, and additionally with daily smoking in women. In Study III, weight concerns predicted subsequent smoking status in low nicotine-dependent smokers only, and the final model explained 12% of the variance of subsequent smoking status. Effects are usually weaker in population-level studies compared to clinical-level studies, thus, this 12% variance represents meaningful variance. The international results regarding smoking-specific weight concerns as a predictor of smoking cessation are mixed. Here, I outline the main underlying aspects behind this disparity. To begin with, smoking-specific weight concerns have been measured with multiple scales, but only the WCSS is validated and tested for reliability in clinical settings (Pomerleau & Snedecor 2008). However, the WCSS does not measure all four dimensions of weight concerns, only dimensions of dieting behaviour to control weight by smoking. A valid measurement of smoking-specific weight concerns is essential for both effective interventions of smoking cessation and research purposes. Therefore, there is a demand for validation of one of the weight concern scales (Germeroth & Levine 2018). One option would be the Borrelli's Weight Concern Scale, because it is applied widely, and additionally, it covers several dimensions of weight concerns: weight gain concerns and dieting behaviours (French & Jeffery 1995, Borrelli & Mermelstein 1998). Measuring weight concerns with the same validated scale would enable the combining of different samples and thus increase the power of analyses.

In this thesis, a modified version of Borrelli's Weight Concern Scale was applied to measure smoking-specific weight concerns (Borrelli & Mermelstein 1998). Similar to our results, many studies applying the original Borrelli's Weight Concern Scale have a high internal consistency (i.e. the scale measures the phenomenon congruently in diverse samples) (Borrelli, Mermelstein 1998, Zhou et al. 2009, Pinsker et al. 2017). Contradictory to our results, in previous studies applying the non-modified version of Borrelli's Weight Concern Scale, weight concerns did not predict smoking cessation (Borrelli & Mermelstein 1998, Faseru et al. 2013, Zhou et al. 2009, Pinsker et al. 2017). Further, Pinsker and colleagues (2017) restricted their study to homeless individuals, so their result is not comparable with the results of this thesis. Whereas, in Borrelli's (1998), Sepinwall's (2004), Zhou's (2009), and Faseru's (2013), reports, analyses were only adjusted for nicotine dependence, but

possible interactions were not tested. This may be one reason behind the discrepancy between their and our results. In addition, Borrelli's, Sepinwall's and Faseru's reports were based on clinical cessation samples (i.e., their participants differed in population and setting). For example, participants in cessation programs are already motivated to quit, but participants in population-based cohorts with smokers are in various stages of change regarding smoking cessation.

In most of the studies with diverse smoking-specific weight concern assessments, weight concerns were not statistically significantly associated with subsequent smoking status (Glasgow et al. 1999, Jeffery et al. 2000, Spring et al. 2004, Faseru et al. 2013, Landrau-Cribbs et al. 2015, Pankova et al. 2016,). The majority of these studies do not report internal consistency of the applied Weight Concern Scales, thus, the measurement of weight concerns may have been incongruent. In addition, a majority of the previous clinical trials did not include a power calculation, thus, the sample size may have been too small to show differences (Glasgow et al. 1999, Jeffery et al. 2000, Spring et al. 2004, Faseru et al. 2013, Landrau-Cribbs et al. 2015, Pinsker et al. 2017). Since these power calculations were not presented, there is a demand to do re-estimation by conducting a systematic review and meta-analyses regarding the association of weight concerns with smoking cessation. Further, the finding that weight concerns did not predict smoking cessation may partly be due to participant selection of the clinical studies. Moreover, in previous studies, nicotine dependence was only adjusted for. However, a possible interaction between weight concerns and nicotine dependence was not tested. As demonstrated in Study III, weight concerns may be a relevant predictor of smoking cessation only for certain sub-groups of smokers, such as those with lower nicotine dependence. The finding that smoking-specific weight concerns predicted subsequent smoking status among low nicotine dependent smokers only is plausible when taking into account the nature of addictions. Nicotine dependence may be such a strong obstacle that it mainly only matters in the smoking cessation among highly nicotine-dependent smokers. Thus, nicotine dependence should always be taken into account when targeting smoking-specific weight concerns in smoking cessation intervention.

In my clinical work, I often meet patients telling me about smoking-related weight concerns as a reason for relapse and continuing daily smoking instead of quitting. In Finland, however, weight concerns are not systematically assessed in clinical settings or adequately taken into account in smoking interventions. The six-item scale to measure weight concerns is too time consuming for clinical use. Likewise, nicotine dependence is also commonly measured with the two-item HSI instead of the six-item FTND (Fagerström et al. 2012, Svicher et al. 2018). A shortened version of Borrelli's Weight Concern Scale should be created. This shortened version should consist of two to three items. Questions two, three, four, and six (original) measure weight concerns better than questions one and five, so the choice of questions should be from the first mentioned. The shortened version should predict smoking cessation as well as the original version to be acceptable to use. In addition, a shortening of the scale is possible and reasonable due to the following two aspects. Firstly, Nunnally and Bernestein (1994, p. 265) posed the following: "In the early stages of

predictive or construct validation research, time and energy can be saved using instruments that have only modest reliability, e.g. 0.7. It can be argued that increasing reliabilities much beyond 0.80 in basic research is often a waste of time and money. Measurement error attenuates correlations very little at that level. Strenuous and unnecessary efforts at standardization in addition to increasing the number of items might be required to obtain a reliability of, say 0.90." In Studies I-III, the Weight Concern Scales' Cronbach's αs were 0.90, so even though internal consistency would decrease to >0.7, it would still be acceptable when targeting the optimisation of time and effort. Secondly, in research settings, if the whole questionnaire contains too many questions, the response rate decreases (Edwards et al. 2007). In this thesis, a shortened version consisting of questions two, three, and four was created. The shortened version predicted subsequent smoking status similar to the applied Weight Concern Scale and had as high an internal consistency as the applied Scale among daily smokers. Further development among clinical settings should be continued.

While weight concerns and motivation to quit were not associated, and motivation to quit predicted smoking cessation only for those with low nicotine dependence in our data, previous studies have reported on this interplay between weight concerns and motivation to quit (Clark et al. 2004, Sepinwall & Borrelli 2004, McKee et al. 2005, McVay & Copeland 2011). Even though weight concerns and self-efficacy had an inverse association in this thesis, self-efficacy predicted smoking cessation only for those with high nicotine dependence, but was not a mediator between weight concerns and subsequent smoking status. Therefore, although in the COM-B model (Michie, van Stralen & West 2011) self-efficacy and motivation to quit are essential predictors of behaviour change, increasing self-efficacy and motivation to quit in smoking cessation interventions may not be sufficient to target when addressing weight concerns as a barrier of smoking cessation. Instead, weight concerns and prevention of weight gain should be targeted to improve cessation rates. Targeting weight control simultaneously with an intervention of smoking cessation improves abstinence rates and reduces weight gain at least as far as three months post-cessation, but from six months on there is no difference when compared to those receiving a smoking cessation intervention only (Spring et al. 2009). In addition, in untreated quitters, weight gain was a reason for relapse for 32% of men and 52% of women (Pisinger, Jorgensen 2007b). In the same study, the relapsing rates due to weight gain decreased into 25% and 37%, respectively, with a lifestyle intervention only or when combined with participation in smoking cessation groups or a smoking reduction course, or a diet and physical activity group. Targeting weight concerns has also improved cessation rates. In two RCTs among women, those who received cognitive behavioural therapy for weight concerns simultaneously with a smoking cessation intervention had higher abstinence rates compared to those receiving a smoking cessation intervention only (Perkins et al. 2001, Levine et al. 2010). The smoking abstinence rate was higher for female participants who received an individually-tailored smoking cessation intervention including both weight-control and cognitive–behavioural weight concern treatments compared to those who received only a smoking cessation intervention with weight-control treatment (Copeland et al. 2006). Thus, weight gain and weight concerns seem to be independent factors affecting

smoking cessation (Levine et al. 2010). In smoking cessation interventions targeting weigh-concerned smokers, both weight concerns and weight control should be taken into account.

6.3 Smoking and abdominal obesity

Excess abdominal obesity is known to be unhealthier than general obesity (Carmienke et al. 2013). In addition, the association with risk of death is stronger when abdominal obesity (i.e., waist circumference) is adjusted for general obesity (i.e., BMI), than when the association is examined for either of these measures alone. Previous literature has also demonstrated strong evidence of the association of current smoking with abdominal obesity in both genders (Berlin 2008, Shi et al. 2013). In addition, a Mendelian randomisation study supports the causality of this association (Morris et al. 2015). Study IV shows that the more unhealthy combination of smoking with overweight/obesity relates more to abdominal obesity than to either of those solely. In addition, Study IV demonstrates whether smokers have health-related reasons to be concerned about their weight. So, the associations between smoking and abdominal obesity were examined to show the association in this Finnish population-based sample. To fully account for BMI, the association between smoking and abdominal obesity was examined according to BMI classification, and additionally adjusted for BMI. The association between smoking and abdominal obesity was shown in overweight/obese women only. In women, heavy daily smokers and ex-smokers had more abdominal obesity compared to never smokers. The reason why we failed to show this in men and normal weight women may be due to some methodological weaknesses. For example, the controlling for alcohol consumption and physical activity may not have been optimal. In addition, we were not able to control sleep quality and the composition of diet at all. All four of these mentioned factors affect abdominal obesity (Emery et al. 1993, Lopez-Sobaler et al. 2016, Asghari et al. 2017).

We showed a rough estimate of the association between CPD and abdominal obesity by showing that heavy daily smokers had higher mean waist circumferences while the occasional and light to moderate daily smokers had no difference in mean waist circumference compared to never smokers in the same BMI category. Also, previous literature has demonstrated similar evidence (i.e., reported on the relationship between increasing CPD and higher abdominal obesity among daily smokers) (Bamia et al. 2004, Pisinger et al. 2009, Clair et al. 2011).

Many previous studies have confirmed the relationship between ex-smoking and abdominal obesity independently of gender (Kwok et al. 2012, Sikorski et al. 2014, Lv et al. 2015, Tian et al. 2015), although in our data this was seen only in overweight/obese women potentially due to the previously mentioned methodological issues. The association of current and former smoking with abdominal obesity is pathophysiologically plausible, and several underlying mechanisms have been described (Filozof et al. 2004, Chiolero et al. 2008, Audrain-McGovern & Benowitz 2011, Harris et al. 2016).

6.4 Methodological considerations

6.4.1 Participants and study design

This thesis aimed to assess weight concerns and abdominal obesity among smokers at a population level. Participants of FINRISK 2007, DILGOM 2007, a subsample of ever-smokers, and DILGOM 2014 formed representative datasets for this purpose.

The overall participation rate for FINRISK 2007 was 67%. Further, of the DILGOM 2007's baseline daily smokers, 65% attended the DILGOM 2014 follow-up, with the overall participation rate being 72%. The participation rates were increased by following-up contact with non-responders, because follow-up contacting is known to increase participation rates (Edwards et al. 2007). The participation rates were at about the same level, or even a little better compared to recent European general sample participation rates (Mindell et al. 2015). The participation rates are a strength of this thesis, because smokers in particular are known to participate less than non-smokers (Christensen et al. 2015), and only a small number of daily smokers dropped out from the follow-up.

In Study II, the associations of weight concerns with motivation to quit and self-efficacy were assessed within a sample of cotinine-verified daily smokers, which was expanded with occasional smokers who had blood cotinine level >10 µg/l. A cotinine level >10 µg/l means that either the person has smoked within about the two previous days prior to the assessment, or were using nicotine replacement therapy (NRT) (SRNT Subcommittee on Biochemical Verification 2002). For current occasional smokers who smoked before on a daily basis, using NRT and smoking occasionally is reasonable, but I assume that those occasional smokers who have never smoked on a daily basis would rarely use NRT. Occasional smokers are less nicotine-dependent compared to daily smokers (Shiffman et al. 2012). In addition, occasional smokers smoke mainly for the positive reinforcement effects of nicotine and have minimal or no withdrawal symptoms (Benowitz 2010). In theory, occasional smokers could use NRT, but I assume this is very rare because NRT use does not include the social component, which is one of the main reasons for occasional smoking (Shiffman et al. 2012b). So, we could not actually distinguish between occasional smokers with elevated cotinine levels due to smoking or NRT use. Prior smoking habits could not been assessed in this cross-sectional sample. We did want to include this cotinine-verified (>10 µg/l) expanded group in the analyses, however, because we wanted to verify smoking status with a biochemical marker. Prior literature has not pooled occasional smokers into daily smokers in such a way. One could state that this pooling of occasional smokers with daily smokers was a limitation in Study II, but the results were similar with analyses including self-reported daily smokers only versus daily smokers with pooled occasional smokers.

A weakness of this thesis is that, since it consisted of a secondary analyses of data collected for smoking research in general and included only a limited assessment of smoking-specific

weight concerns (six questions of unknown reliability) and no questions about general weight concerns, it provides less precise measures of the concept than is desirable. In addition, considering Study III, no measurements at intermediate timepoints between the 2007 baseline and follow-up at 2014 were available. Thus, the level of weight concerns may have been varying at different timepoints during the seven-year follow-up.

Three of the studies (Studies I, II, and IV) in this thesis are cross-sectional, with only associations able to be demonstrated, while Study III is longitudinal, thus allowing causality between a predictor and outcome to be assessed to some extent. However, it should be acknowledged that the observational study design is not sufficient for confirming causal associations.

6.4.2 Measurements

Weight Concern Scale

The fact that the Weight Concern Scale applied was slightly modified from the original, and the sum score ranged from 0 to 24, instead of the original mean from 1 to 10, are among weaknesses of the measurements used in this thesis. The original sixth question "How likely is it that you would go back to smoking after quitting if you gained too much weight?" was replaced with a question "How important is replacing meals with cigarettes/snus for your weight control?". Borelli's Weight Concern Scale was developed for treatment studies of smoking cessation and, by changing the final item, the questionnaire was more applicable for population-based settings, where not all of the smokers were planning to quit in the near future. In addition, by changing the final question, a question assessing actual weight control could be included. Comparison between the results of Studies I–III and other studies, however, would be more accurate without these modifications. The internal consistency of our modified Weight Concern Scale was high, indicating that all items measured weight concerns in a consistent way. In addition, although ex-smokers (recent quitters, former smokers) were instructed to answer according to the time while they were smokers, this Scale more poorly measures their weight concerns than it does among current (occasional, daily) smokers. For example, they already know how much weight they gained during the cessation process, and they did not relapse back to smoking due that. Thus, their weight concern scores might be confounded because of actual weight gain, and might not solely reflect their weight concerns before quitting. Finally, the original Borrelli's Weight Concern Scale is not validated, let alone our modified scale.

Weight, height, and waist circumference

Weight, height, and waist circumference were measured by research nurses. This is a strength of this thesis because disparity between measured and self-reported weight, height (Connor Gorber et al. 2007) and waist circumference exists (Lu et al. 2016). Weight and waist circumference are usually under-reported (Connor Gorber et al. 2007, Lu et al. 2016),

while height is over-reported (Connor Gorber et al. 2007). Thus, in Study IV, applied BMI and waist circumference measurements were as accurate as possible.

Self-efficacy and motivation to quit

Self-efficacy to quit was measured by a single question "If you were to try to quit smoking, how much confidence would you have that you could quit it for good?". This wording was adequate, and predictive value of self-efficacy to quit for subsequent smoking was found to be better with assessment by one question rather than series (Gwaltney et al. 2009). Finally, no data at intermediate timepoints between baseline and follow-up were available, during which time self-efficacy and motivation to quit may have changed before the actual cessation. In addition, self-efficacy predicts proximal behaviour better than distal behaviour (Gwaltney et al. 2009). Also, motivation to quit was measured by a single question "How willing are you to quit smoking for good?". One of the potential problems was caused by the original Finnish wording, since the term "willing" ("halukas" in Finnish) differs from "motivated" ("motivoitunut" in Finnish) and may measure actual motivation insufficiently.

Smoking status

One of the main strengths of this thesis is that we were able to use the following five smoking categories: daily smokers, occasional smokers, recent quitters, former smokers and never smokers (Study I). In addition, the following four categories were used in Study IV: never smokers, ex-smokers, occasional smokers and light/moderate daily smokers, and heavy daily smokers. These specific categories made it possible to examine weight concerns and abdominal obesity in more detail.

The formation of smoking categories was mainly self-reported, biochemical verification was available only for some of the participants. Smoking categories were formed with multiple questions, making the smoking status assessments more reliable. Only a few ever-smokers had major inconsistencies in their answers regarding smoking, and therefore were excluded from the study. Current smoking may be underestimated when measured by self-reporting (Connor Gorber et al. 2009). However, in an earlier Finnish study at a population level, the validity of self-reported smoking status was high (Vartiainen et al. 2002). CO is useful for distinguishing smokers from non-smokers, regardless of NRT use (SRNT Subcommittee on Biochemical Verification 2002). Further, as reported in Study III, the reliability of self-reported smoking status was very high among those 128 participants with CO measurements available; no self-reported ex-smokers had a CO level above the recommended boundary of ≥8 ppm (SRNT Subcommittee on Biochemical Verification 2002). Biochemical verification for all participants would certainly have been valuable in this thesis.

The prevalence of daily smokers in FINRISK 2007 was 23% among men and 19% among women (Peltonen et al. 2008a), which is quite similar to the result of another Finnish population-based sample of adults (26% and 17%, respectively, in the Health Behaviour

and Health among the Finnish Adult Population 2007 study) (Helakorpi, Prättälä & Uutela 2008). So, if a reporting bias in daily smoking status exists, it was quite similar to the other Finnish population-based health survey.

Nicotine dependence

Nicotine dependence was measured by applying the FTND (Fagerström 1978, Heatherton et al. 1991), which is a valid and reliable method to assess nicotine dependence (Pomerleau et al. 1994, Etter 2005, Svicher et al. 2018). In Study III, smokers were grouped according to nicotine dependence level and analyses were further controlled for it, whereas Study II only controlled for FTND. Assessing nicotine dependence in addition to smoking status is one of the strengths of this thesis.

Confounders

Some confounding variables, such as physical activity and fat and fibre intake, were assessed with multiple questions, increasing the reliability of the reported characteristics. However, alcohol consumption is a more unreliable variable. Firstly, alcohol consumption is known to be underreported (Christensen et al. 2015). Secondly, for Study I, self-reported use of alcohol products in the previous 12 months was further calculated as the average daily alcohol consumption in grams. This is unreliable due to recall bias, as participants have not been able to remember exactly what they had drunk in the previous 12 months. For Studies III and IV, alcohol consumption was assessed in a more reliable manner, since the self-reported use of alcohol products in the previous week was assessed.

7 Conclusions and implications for further research and health promotion

Based on the findings presented in this thesis, I conclude the following matters in population-based settings. Daily smokers have more weight concerns than other ever-smokers. Weight concerns are associated with a lower self-efficacy to quit, but not with motivation to quit. Weight concerns predict lower success for smoking cessation and decreasing usage into occasional smoking status, but only for low-nicotine-dependent smokers. Among overweight/obese women, daily smokers and ex-smokers have more abdominal obesity than never smokers.

A shortened version from Borelli's Weight Concern Scale should be created and examined. If a two- to three-item measure is as accurate in predicting smoking cessation as the full-length scale and has internal consistency $\alpha>0.7$, the usage of a shorter version would optimise time and effort, especially in clinical settings. In addition, a validation of weight concerns assessment is required. Further, weight concerns as a predictor for cessation in primary healthcare or occupational healthcare settings in Finland demand examination. In clinical settings, a smoking cessation intervention additionally addressing weight concerns and weight control should be created to promote secondary level prevention, and thus be available for primary healthcare and occupational healthcare sectors. In addition, in primary and occupational healthcare, the preventive interventions should focus more efficiently on those with multiple risk factors, such as heavy smoking and abdominal obesity. Finally, a systematic review and meta-analysis should be conducted to pool the results and present a more precise estimate of weight concerns as a predictor of smoking cessation.

At the public health level, raising awareness of weight concerns and healthier weight control among smokers may help in removing an obstacle to smoking cessation. Smoking-related weight concerns could be addressed, for example, by a social media campaigns, which contain material about healthier ways to manage one's own weight and prevent excess weight gain during smoking cessation. In addition, such content should include material about the fact that, in general, smoking is unhealthier than being overweight, and further, that heavy smokers and ex-smokers have more abdominal obesity. Public health actions should aim to prevent and reduce the clustering of unhealthy habits, such as smoking and overweightness/obesity, in the same people.

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